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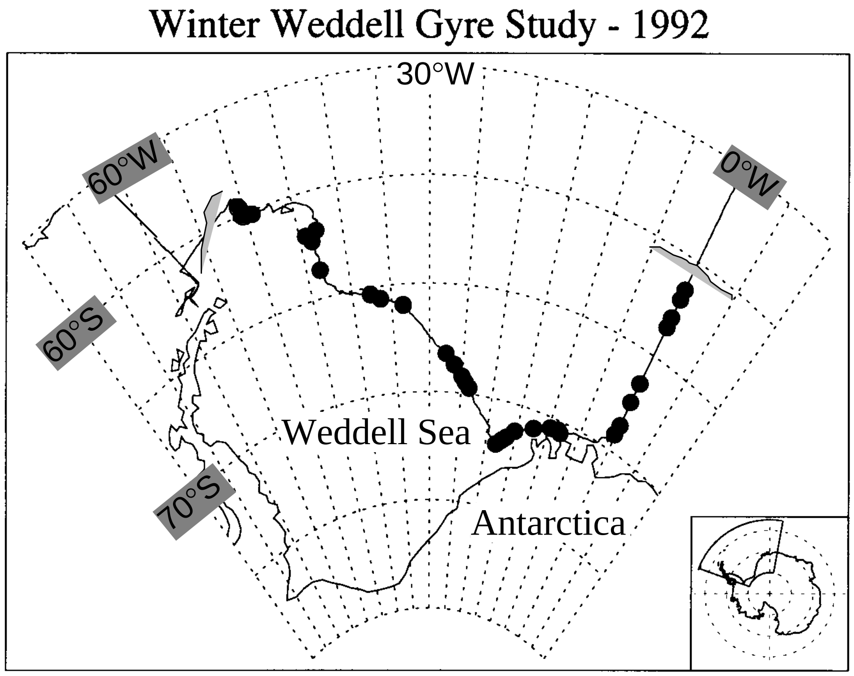

Snow, Sea-ice, and Radar Observations: Summary Data Report

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Winter Weddell Gyre Study 1992

Foreword

This report comprises data from sea-ice coring and thickness drilling and radar backscatter measurements made during the Winter Weddell Gyre Study Ant X/4 expedition of the icebreaker RV *Polarstern.* The following persons were involved in the ice-work (in alphabetical order):

Wolfgang Dierking	Alfred Wegener Institute
Mark Drinkwater	Jet Propulsion Laboratory, California Institute of Technology, USA
Christian Haas	Alfred Wegener Institute
Alan Lohanick	Cold Regions Research and Engineering Laboratory, USA
Rob Massom	Scott Polar Research Institute, UK
Christian Schulte	University of Bremen
Markus Thomas	University of Hannover

Eva-Maria Nöthig kindly provided all Chlorophyll-a data. Petra Heil and Nadja Steiner of Kiel University are also acknowledged for their contributions to these field measurements.

CONTENTS

1. Introduction

This report summarises the main observations of the sea-ice and microwave radar shipborne programs during the Winter Weddel Gyre Study 1992 (WWGS '92). It provides a listing of these measurements at each site throughout the course of WWGS '92. Together with a report of general ice conditions, which comprises visual observations from the ships bridge and imagery of satellite-based SSM/I, AVHRR and SAR sensors (Haas *et al.*, 1992), it is compiled to provide a database for scientists wanting to work in this region.

The 1992 Winter Weddell Gyre Study was an austral winter cruise conducted in the Weddell Sea, Antarctica by the German icebreaker RV *Polarstern*. (Leg ANT X/4, Lemke, 1994). During the course of this experiment, various programs were conducted including sea ice and oceanographic measurements, the deployment of drifting buoys, a 3-day drift station, and acquisition of remotely sensed and surface measurements simultaneous to overlapping data collection by the European Earth Remote Sensing (ERS-1) satellite and Defense Meteorological Satellite Program's Special Sensor Microwave Imager (SSM/I). The latter project was a part of an International Space Year (ISY '92) project conducted in coordination with the European Space Agency.

WWGS'92/Ant X/4 was conducted along an oceanographic transect across the Central Weddell Sea, sampled repeatedly by RV *Polarstern* as part of the World Ocean Circulation Experiment (WOCE). The track of the vessel is shown in Fig. 1, beginning in the east with a southward bound leg at the end of May 1992, following the 0° meridian to the Antarctic coast. This track turns west-south westwards along the ice shelf, reaching 73°S at point **A** by the end of June, 1992. At this southernmost location a northwestward course was selected to cross the Weddell Sea towards the South Orkneys. This path is interrupted only by a small course change at waypoint **B** and a 3-day drift station performed at location **C**. After passing around the islands, the ice edge was exited on 29 July, 1992 in the vicinity of location **D** in Fig. 1.

WWGS '92 was the second austral winter experiment of its kind, following a similar theme to a Winter Antarctic experiment conducted in 1986 by RV *Polarstern* (Schack-Schiel, 1987) and the first Winter Weddell Gyre Study conducted in 1989 (Augstein *et al.*, 1991).

The main goals of the sea-ice programme during WWGS ´92 were to investigate the energy- and mass-balances of Antartic sea ice in winter, to improve knowledge on sea-ice growth mechanisms and ice dynamics, and to provide surface validation data for the different shipborne and spaceborne microwave remote sensing measurements which were carried out simultaneously during the shipborne experiment. The sea-ice related programme consisted of the following main components:

- Ice coring and subsequent laboratory analysis
- Snow and ice thickness measurements
- Shipborne microwave radar scatterometer measurements
- ERS-1 and SSM/I surface validation measurements
- Shipborne passive microwave radiometer measurements
- Shipborne optical and thermal infrared measurements
- Standardised ice observations from the ship´s bridge

Detailed sea-ice and snow measurements were routinely made by various scientists aboard the ship at each stopping location along the route of the vessel (see Table 2). The following sections summarise data from the first three items in the list shown above. Standard visual ice observations of sea-ice conditions were made en-route by ice observers, from the bridge of RV *Polarstern*. The details of these observations are recorded in Haas *et al.* (1992).

2. Ice Core Analysis and Thickness Measurements Summary

Figure 1 shows the route taken during Ant X/4. Symbols plotted along the length of the RV *Polarstern* track indicate snow and sea-ice characteristics measurement sites. A legend indicates the main ice categories found in the Weddell Sea at each site along the ship track. This section provides a general summary of the ice and snow conditions as revealed by ice core analysis and thickness measurements. A detailed listing of the individual site data can be found in the Appendix.

Winter Weddell Gyre Study - Ant X/4 Polarstern Track

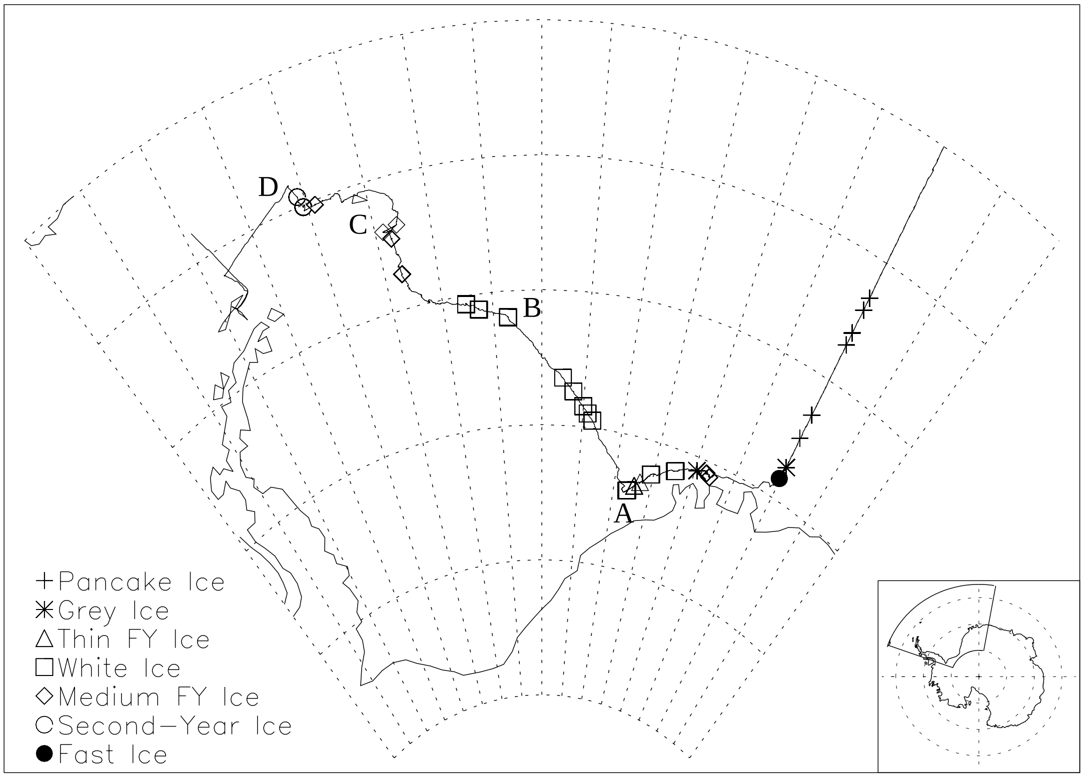

Figure 1. Map showing the track of RV Polarstern and the principal ice types observed along the route.

2.1 Ice Thickness Measurements

Snow and sea-ice thickness measurements were made during WWGS '92 to obtain information about ice mass, isostasy and roughness, all of which are important parameters in dynamic and thermodynamic atmosphere-ice-ocean interaction processes. At each site location, a standard ice auger was used to drill a hole though the ice to enable a measurement to be made using a standard ice thickness gauge. At each of these sites the corresponding sea-ice freeboard, snow depth and ice draft were noted and compiled in a database together with ice core properties data shown in the subsequent sections. In addition to individual auger measurements, more detailed profile measurements were made at a limited number of sites. Profile data (as presented in the Appendix) comprise several sampled transects up to 100 m long with snow and ice thicknesses and draft/freeboard measurements at a spacing interval of 1.0 - 2.0 m. Additional randomly-spaced drillings on one floe or by means of helicopter ´floe hopping´ gave information about the thickness distributions over a wider lateral range.

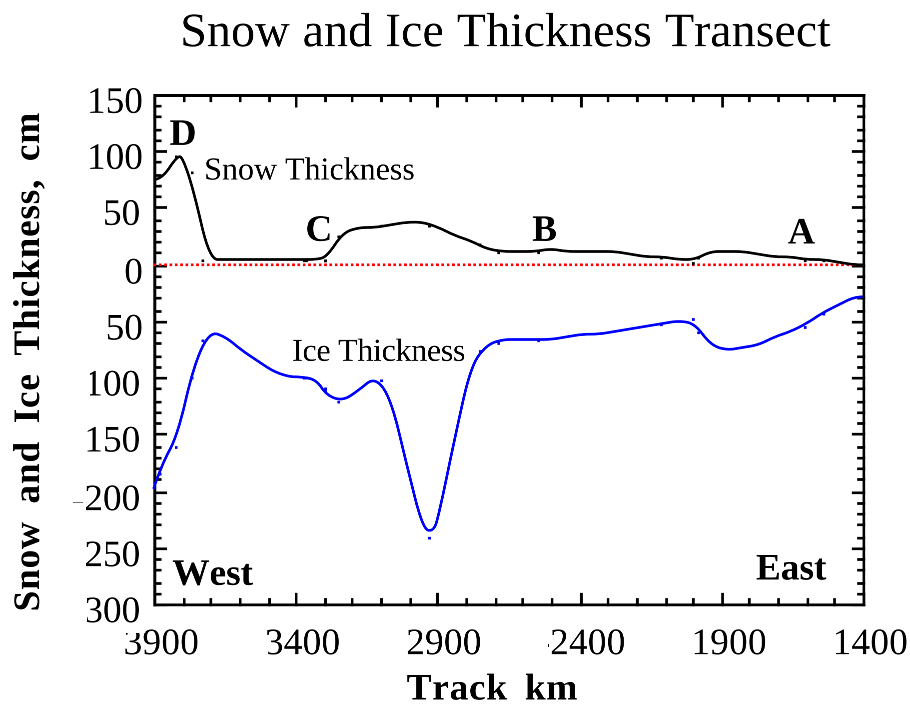

Figure 2. Mean sea-ice thickness and snow depth from sampling sites visited along the RV *Polarstern* ship track, with location indicators A - D, shown in Figure 1. Thicknesses are referenced to 0 m and are not corrected for freeboard. Curves shown are interpolated through the mean data points along track.

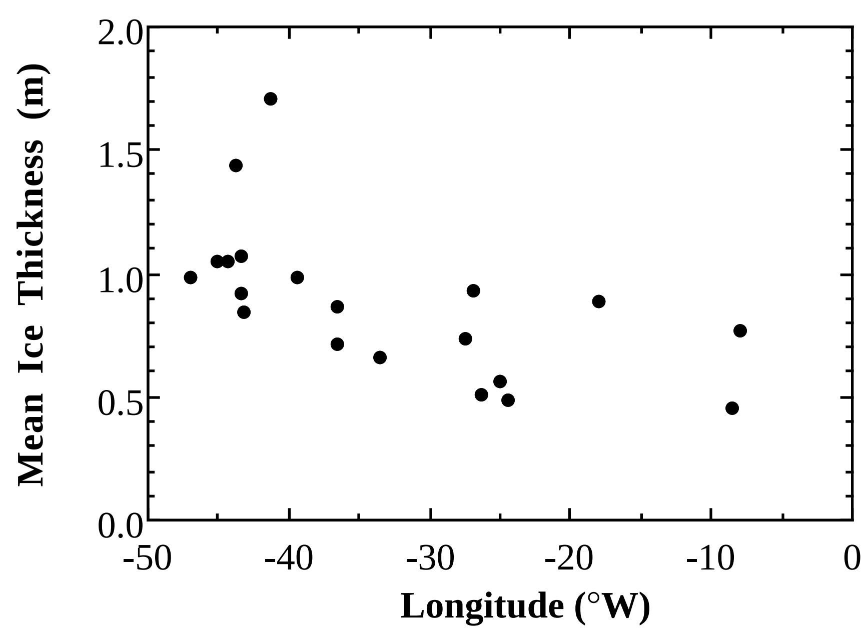

Figure 3. Mean ice thicknesses along the zonal transect.

Figure 2 shows snow and ice thicknesses corresponding with the 2500 km transect between points **A** and **D** along the ship track in Figure 1. Corresponding photographs of ice conditions along this path are shown in Haas *et al.* (1992). Figure 2 illustrates that Eastern Weddell Sea ice comprises ice almost less than 70 cm thick. White ice of around 50 cm thick was the most predominant variety of first-year (FY) ice, especially between waypoints **A** and **B**. Such locally formed ice also had a shallow snow cover typically less than 20 cm deep. Moving northwestwards beyond waypoint **B**, a band of mixed-ice forms was crossed. This comprised undeformed second-year, smooth medium-thick first-year (50 - 120 cm thick) and well-deformed, rough first-year (FYR) ice floes. The latter had mean ice thicknesses exceeding 2.0 m in places. Between location **C** and **D** a swath of thinner FY ice is observed with little or no snow cover before another band of thicker undeformed, low-salinity second-year (SY) ice was encountered. Drinkwater *et al.* (1993) show with images from ERS-1 that this location is one of the principal regions of winter outflow of old ice from the Weddell Sea. Radar images identify the old ice by its relativelyhigh backscatter, due the extremely deep, layered snow cover recorded on such flat, high freeboard floes.

In Figure 3 the longitudinal distribution of measured mean ice thicknesses is presented, which, in parts, resembles the ice thickness distribution shown in Figure 2. Again, ice thickness can be seen to increase with increasing longitude due to the larger amount of second- and multi-year ice which is transported within the Weddell Gyre to the northwestern Weddell Sea.

Mean ice thickness for all measurements was found to be 0.88 m with corresponding means of 0.13 m and 0.05 m for mean snow depth and freeboard, respectively.

Figure 4 presents the overall probability density functions (PDF´s) of total thickness including ice and snow (a), ice thickness (b), snow thickness (c) and freeboard (d) for all of the data. Closer inspection of the dataset suggests that the sampled floes were mainly composed of deformed first-year ice (0.89 m mean thickness) and undeformed first- (0.72 m) and second- (1.23 m) year ice which may be identifiable in the total thickness PDF. The abundant occurence of negative freeboard (Fig. 4d) demonstrates the high probability of flooding and snow ice formation in the Weddell Sea.

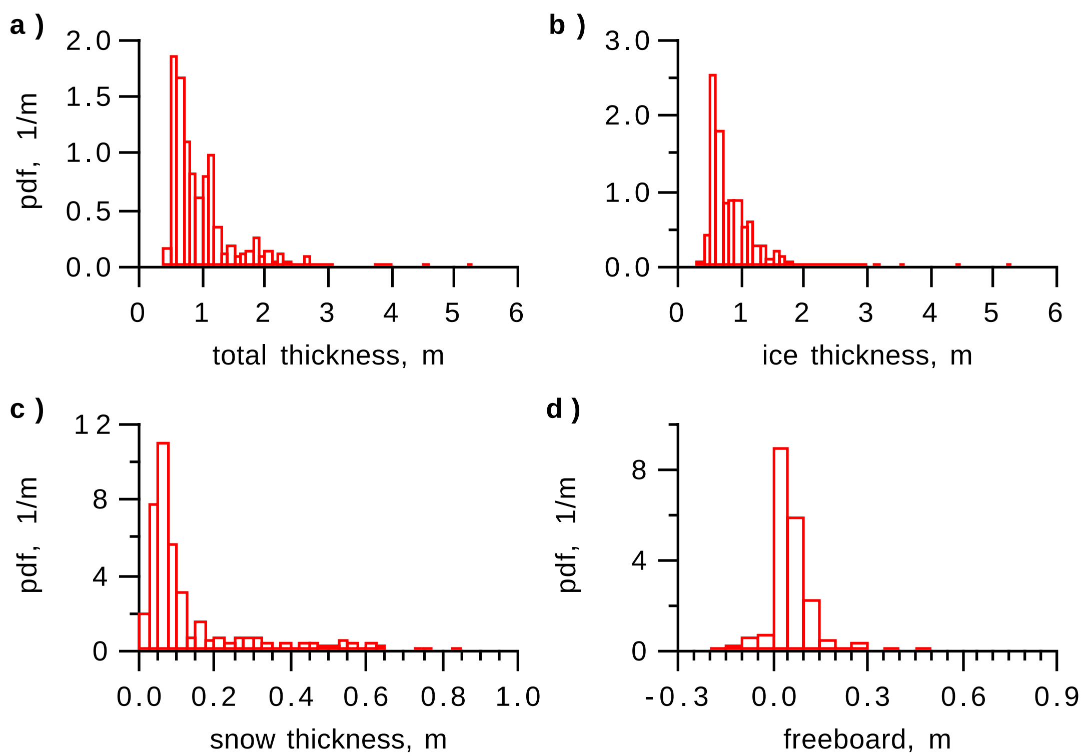

Figure 4. Probability density functions for several parameters for the complete dataset.

2.2 Ice Core Processing

Ice cores were obtained from a total of 38 stations to measure several physical and chemical parameters (Table 2). On the ice, temperature profiles were carried out, immediately after each ice core was taken. Detailed analyses were then performed in a -25°C cold lab on the ship, including texture analysis and qualitative pore size and distribution discription with the aid of thick sections. For subsequent quantification, thin sections were produced. In addition, salinity, Chlorophyll a and nutrient concentrations were measured. Subsamples were retained for later δO^{18} and density measurements.

Table 1. Summary of the observed proportions of the different textural classes observed during WWGS '92

Ice Texture	Frequency of occurence
polygonal granular	1%
orbicular granular	47%
mixed columnar/granular	9%
intermediate columnar/granular	3%
columnar	38%
platelet	2%

Table 1 summarizes the occurence of different texture classes as found in all analysed cores. Due to the early winter season, most ice was comprised of orbicular granular ice. In the course of the winter, the portion of columnar congelation ice can be expected to increase. Figure 6 shows the observed spatial distribution of ice texture classes along the cruise track. While the ice was mostly of frazil origin in the Eastern Weddell Sea, according to the so-called ´pancake cycle´, congelation growth seems to dominate in the central Weddell Sea.

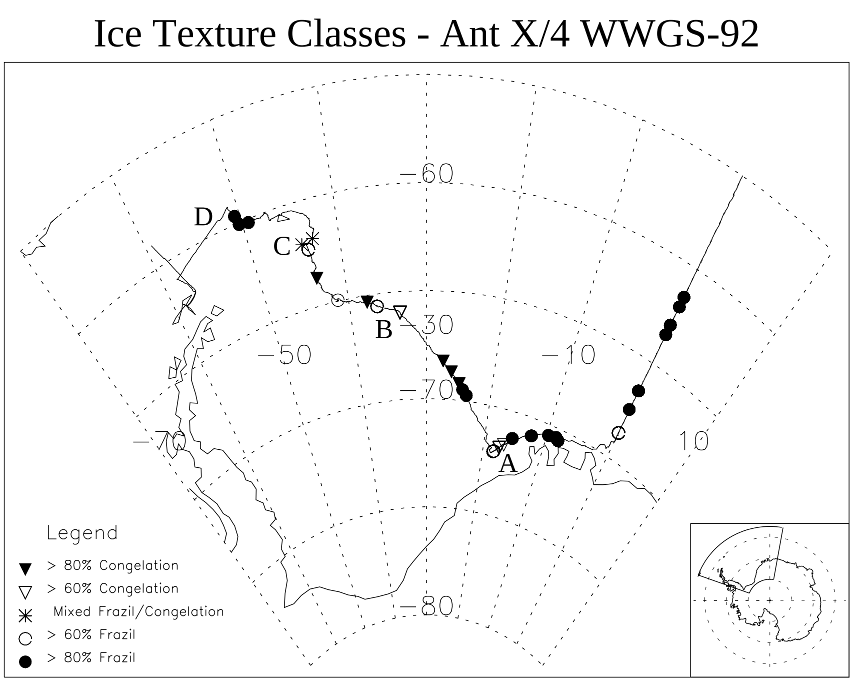

Figure 6. Spatial distribution of sea ice texture classes along the cruise track

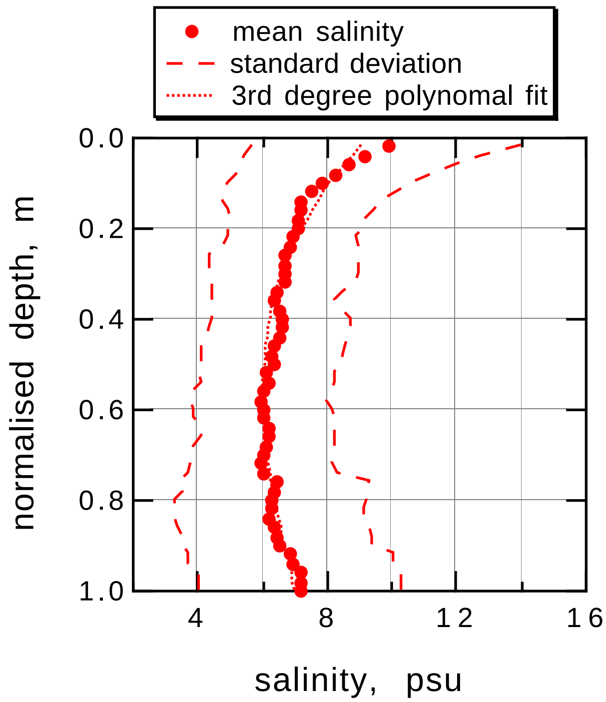

Figure 5. Composite mean salinity profile of all ice cores. Solid circles represent the mean, long dashes the standard deviation, and a dashed line represents a 2nd degree polynomial fit to the means.

Figure 5 shows the composite mean salinity profile of all analysed cores together with the standard deviation and a 3rd degree polynomial fit. Although many cores showed an S-type shape, the C-type shape which is typical of first year ice in the Weddell Sea can be clearly seen in the composition of all of the cores. The mean salinities for all of the cores was 5.67 ppt for true and 6.76 ppt for normalized lengths respectively.

3. Microwave Radar Scatterometry

Radar backscatter data were acquired using a shipborne C-band microwave scatterometer. Radar observations were coupled with atmospheric and oceanographic measurements so that direct links between physical, chemical and dielectric properties of the sea ice and the flux regime could be investigated. The C-band (4.8 GHz) frequency-modulated continuous-wave (FM-CW) radar scatterometer was operated from the port rail of Polarstern to obtain some of the first shipborne measurements of the microwave scattering properties of Antarctic sea ice in mid-winter. The radar had dual polarization, enabling like- (VV) and cross-pol (HV) data to be acquired at a variety of incidence angles (10-70°). When the ship was stationary, and on station by an ice floe, the radar was scanned to obtain backscatter measurements as a function of both angle and polarization.

The objective of this investigation was to provide validation data for the ERS-1 C-band synthetic aperture radar (SAR) observations (at 20° - 26° incidence) and to obtain a detailed microwave backscattering dataset for computer modelling purposes. In support of this programme, detailed surface measurements were made within the footprint of the radar, each time a radar scan was completed. This information comprises snow and ice physical and chemical properties measurements together with structural information. Simultaneous data acquisitions were planned and made by the ERS-1 SAR, via use of the German Antarctic

receiving station as part of the ISY Project (Lemke, 1994).
Figure 7 illustrates typical mean signatures contructed from all samples sites with shipborne scatterometer measurements of similar ice conditions. Sample data shown in the Appendix were grouped into similar ice thicknesses and roughness categories and averaged. The resulting mean signatures shown are fitted backscatter curves using an exponential decay model in Figure 7. Results clearly show that there is considerable confusion between Second-year (SY) and Rough First-year (RFY) sea ice, especially in the 20 - 26° incidence range where ERS-1 measures backscatter using its Synthetic Aperture Radar (SAR). Nevertheless, thinner, undeformed and thus smoother ice forms can be clearly recognised from the thicker, deformed ice groups, and the most predominant white ice form (30 - 70 cm thick) is clearly lower than the other signatures.

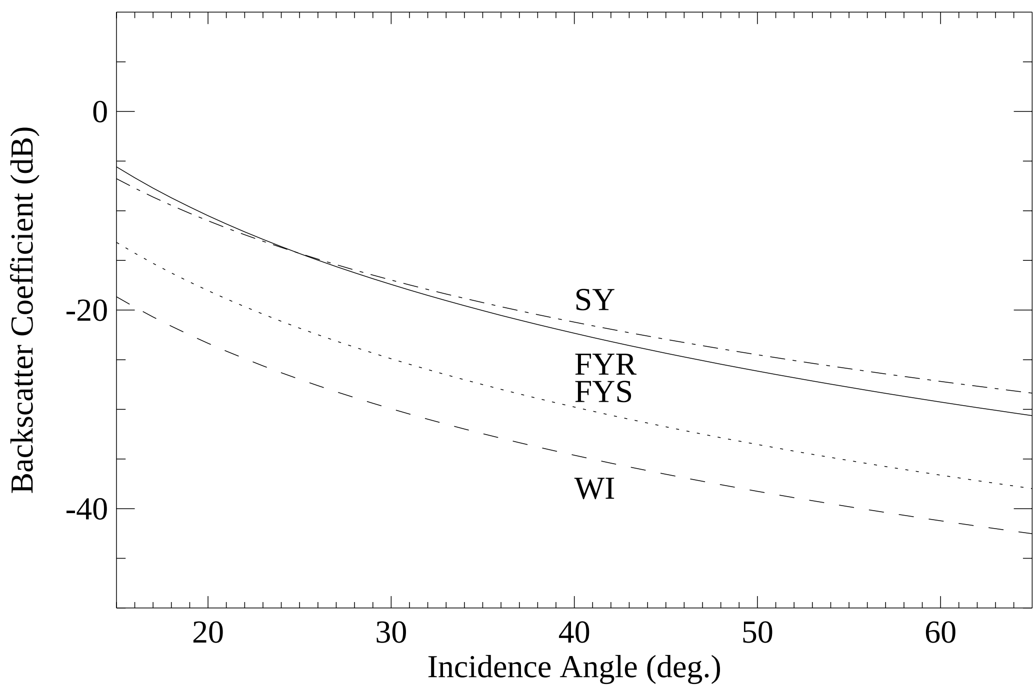

Figure 7. Summary of backscatter characteristics of various major ice types observed as shown in Figure 1. WI, FYS, FYR, SY denote white, smooth first-year, rough first-year and second-year ice respectively.

At short ice stations, combined radar and snow and ice measurements were made of a number of ice types characteristic of the Weddell Sea during the wintertime: these include undeformed snow-covered grey and white first-year ice, together with second-year and possible fast ice forms each with extreme snow loading; other ice forms included ridged and rafted white ice and hummocked second-year floes. A 3-day long ice station from 21-24 July, 1992 offered the possibility of making time-series observations of the sea ice with the scatterometer. In addition to periodic scans of data over the complete range of incidence angles, the radar was operated at frequent intervals (approximately 4 hourly) at a fixed incidence angle of 45°, and at both polarizations. The angle was chosen because the radar responds sensitively to the surface reflectivity and roughness, and is also sensitive to volume scattering from the snow and ice surface layers. Preliminary results indicate that the radar backscatter shows strong correlations with surface properties measurements and especially the thermal conditions in the upper ice and snow. Large temperature changes noted during the ice station offer the possibility of modelling studies which demonstrate links between the combined active and passive microwave characteristics and the heat flux component in the surface energy balance.

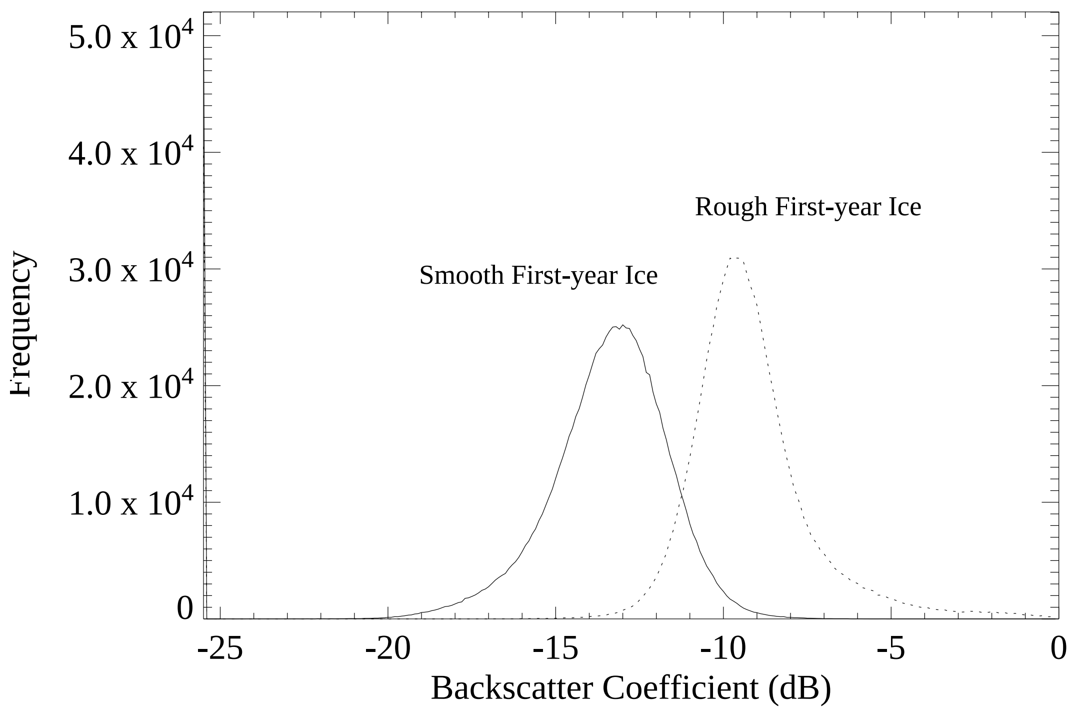

Figure 8. Plots of image histograms of deformed and undeformed ice regimes in the Weddell Sea.

Comparative ERS-1 data from calibrated images shows similar trend, with smoother ice forms having predominantly lower backscatter values. An ERS-1 SAR image with rough first-year ice is analysed from a location near the coast of the in the Eastern Weddell Sea (at 72°S 15°W), where Polarstern traversed extremely deformed first-year ice (Haas *et al.*, 1992). The mean value in the image backscatter distribution exceeds -10 dB, in contrast to the mean smooth first-year ice signature from an image in the Central Weddell Gyre (at 68°S 23°W), where the mean is below -13 dB. Both images were acquired in July during the Polarstern cruise, and are typical mid-winter signatures of first-year ice. There is a noticeable difference between the ERS-1 and the 20-26° shipborne scatterometer mean backscatter values, in that ERS-1 image distributions show a higher mean value than the smooth ice examples observed using the shipborne C-band instrument. The explanation is that the ship scatterometer measurement scans were normally encompassed within single smooth and undeformed ice floes and ERS-1 pixel scaling and sampling of mixed pixels biases the means of smooth ice in the ERS-1 images towards slightly higher values. Thus, when nilas ice or white ice exists in narrow leads or as small ice floes ERS-1 pixel values are expected to exhibit higher means. ERS-1 SAR image distributions show the lowest backscatter values in a tail which extends below -20 dB. Individual pixel values can be found which exhibit similar values to those in the range shown in Figure 7, but are all contained in the tail towards lower values, with minimum values of around -25 dB in the case of the image in the Central Weddell Gyre. The noise-floor of the ERS-1 instrument is around -23 dB and so the lowest observable signature from ERS-1 SAR is restricted to $\sigma°$ values exceeding this limit.

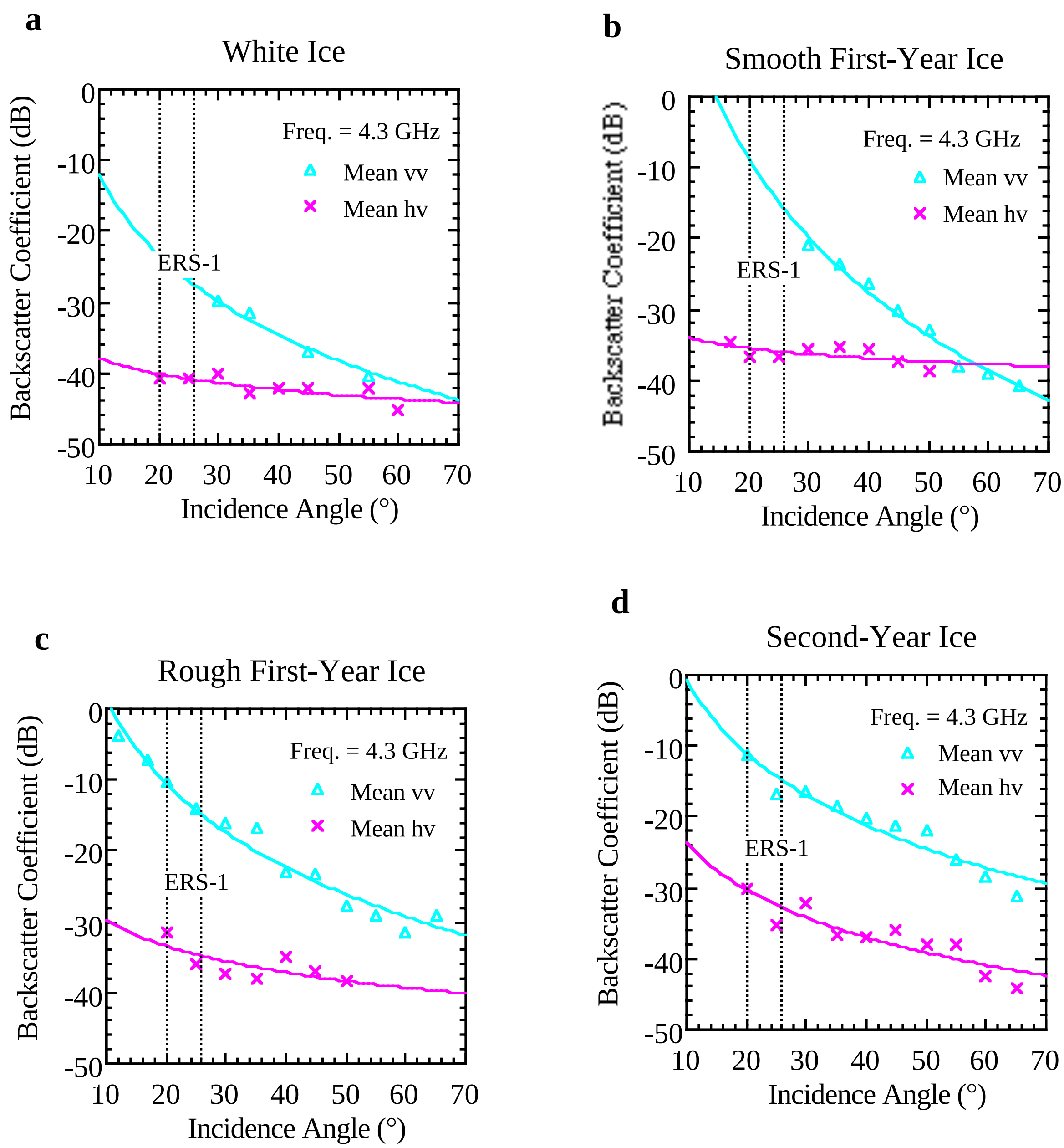

Figure 9. Plots of mean WWGS'92 shipborne scattering signatures, from (a) White ice, (b) smooth first-year ice; (c) Rough first-year ice; and (d) Second-year ice. Curves are fitted exponentially and dotted lines indicate the incidence angle range of ERS-1 SAR.

Figure 9 illustrates the typical mean signatures from WWGS'92, after all the shipborne scatterometer data were grouped by similar ice conditions and types, and similar radar scattering conditions. The averaging resulted in a smoothed signature representative of the four ice classes shown, and the exponentially fitted smooth curves represent the mean signatures of each ice type. Results indicate that ice age and thickness in the general undeformed first-year ice category is significantly related to the backscatter values themselves. Generally the backscatter increases with ice thickness and age, in relation to the salinity content of the sea ice. Clearly, in the case of second-year ice with typically deep snowcover, there is confusion with rough, deformed first-year ice.

4. Acknowledgements

Sincere thanks are expressed to all on board *Polarstern* who supported in the acquisition of field data. Especial thanks go to Captain Jonas, his crew, and the scientific cruise leader Peter Lemke. Prasad Gogineni and Reza Hosseinmostafa of Kansas University are thanked for use of the field scatterometer instrument, and for supporting the analysis of the Weddell Sea microwave signatures. Hajo Eicken is acknowledged for making possible the participation of Christian Haas and the conduction of an ice coring program. Robert Thomas of the Cryospheric Branch of Code YSC NASA is thanked for support of Mark Drinkwater (MRD) during participation in the experiment. MRD performed this work as visiting scientist at the Alfred Wegener Institute while on Foreign Assignment from the Jet Propulsion Laboratory, California Institute of Technology and under contract to NASA.

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Table 2. Summary of Ant X/4 Polarstern measurement site locations. The list comprises stations where ice- or remote sensing-related experiments were conducted, as indicated by the keywords below.

Station List ANT X/4

Station No.	Date (GMT)	Start Time	Start Position		Depth (m)	Work
21/586	12.06.92	11:40	61°30.0'S	00°00.7'W	5379	IB/CTD
21/587	12.06.92	19:45	62°00.5'S	00°00.2'W	5357	IB/CTD
21/589	13.06.92	08:10	63°00.2'S	00°00.4'W	5299	IB/CTD/SC
21/590	13.06.92	17:06	63°30.3'S	00°00.4°E	5233	IB/CTD
21/596	15.06.92	11:27	66°30.1'S	00°00.9°E	4531	CTD/MC
21/598	16.06.92	06:16	67°30.2'S	00°00.4°E	4621	CTD/MC
21/602	17.06.92	12:03	68°44.7'S	00°01.5°E	3641	ICE/CTD/SC
21/604	18.06.92	10:00	69°14.6'S	00°02.7'W	2605	ICE/CTD
21/607	21.06.92	08:48	70°32.3'S	08°02.1'W	197	ICE/SC
21/608	22.06.92	07:11	70°32.3'S	08°02.3'W	196	ICE//SCSC
21/609	25.06.92	14:30	70°27.5'S	08°31.8'W	317	ICE
	26.06.92					ICE
21/613	01.07.92	11:59	70°48.8'S	12°18.4'W	2028	ICE/CTD
21/614	05.07.92	13:00	71°38.0'S	16°35.0'W	2428	ICE
21/615	07.07.92	09:45	72°03.0'S	18°06.6'W	2771	ICE/SC
21/616	10.07.92	06:00	69°44.1'S	23°46.7'W	4591	ICE/DEPL-9369/ RR/SC
21/617	10.07.92	10:40	69°30.1'S	24°24.7'W	4670	ICE/RR
21/618	10.07.92	14:18	69°15.2'S	25°03.2'W	4696	ICE/DEPL-9365/ RR/SC DEPL-9368(Heli)/ CTD/RR
21/619	11.07.92	00:06	68°58.7'S	25°41.5'W	4740	RR
21/620	11.07.92	05:32	68°44.3'S	26°18.8'W	4739	ICE/DEPL-9364/SC DEPL-9367(Heli)/ CTD/RR
21/621	11.07.92	13:49	68°29.7'S	26°57.6'W	4741	ICE
21/622	11.07.92	19:58	68°14.6'S	27°34.8'W	4729	ICE/DEPL-9366/RR
21/623	13.07.92	14:30	65°59.4'S	33°29.8'W	4777	ICE/CTD/SC
21/625	14.07.92	19:05	65°35.1'S	36°27.1'W	4769	ICE/CTD/SC
21/626	15.07.92	13:12	65°17.2'S	37°40.6'W	4769	ICE/CTD/SC
21/628	17.07.92	14:21	64°56.0'S	41°20.3'W	4741	ICE/CTD/SC
21/630	19.07.92	07:12	63°43.5'S	43°24.5'W	4060	ICE/CTD/SC
21/634	21.07.92	07:21	62°20.5'S	43°41.1'W	1174	ICE/CTD/SC
21/635	21.07.92	19:00	62°01.2'S	44°17.8'W	656	ICE-LST-start/ CTD/SC
	24.07.92	18:00	61°52.9'S	43°00.3'W		ICE-LST-end/CTD/SC
21/637	26.07.92	15:00	60°26.1'S	46°59.8'W		ICE
21/642	27.07.92	16:50	60°10.3'S	49°19.4'W	1214	ICE/CTD/SC
21/645	28.07.92	08:00	60°05.6'S	50°18.5'W	2793	ICE/MU/SC
21/646	28.07.92	13:35	59°51.8'S	50°31.9'W	3830	ICE
21/647	28.07.92	17:30	59°39.3'S	50°29.9'W	3818	ICE/SC
21/648	29.07.92	08:20	59°08.1'S	50°57.4'W	2830	ICE/CTD

ICE = Ice Station; ICE-LST = Long Drifting Ice Station; IB = Ice Basket; MC = Mummy Chair Coring; DEPL-XX = Deployment of Drifting Buoy; RR = Deployment of Radar-Reflector; and CTD = Conductivity-Temperature-Depth Ocean Profile; SC = Radar Scatterometer Measurements.

Table 3. Legend to Ice Cores Listed in the Appendix.

Texture Legend

Orbicular Granular

Columnar

Mixed Orbicular/Columnar

Polygonal

Platelet

DATA APPENDIX

Each of the following dates indicates a site at which various measurements were made. The listing given is a desciption of some of the general observations at each site, together with the shipborne scatterometer data scan and the ice core analysis.

12 June 1992: N0416401

Ship Station Number:	21/586	Air Temperature (°C):	-5.70
Time:	11:40	Snow Surf. Temperature (°C):	
Latitude:	61°30.0'S	Snow Thickness (m):	
Longitude:	00°00.7'W	Total Ice Thickness (m):	0.20
		Freeboard (m):	0.01

Notes
Pancake of 1m diameter, sampled with ships crane.
Seawater salinity 34.32 psu

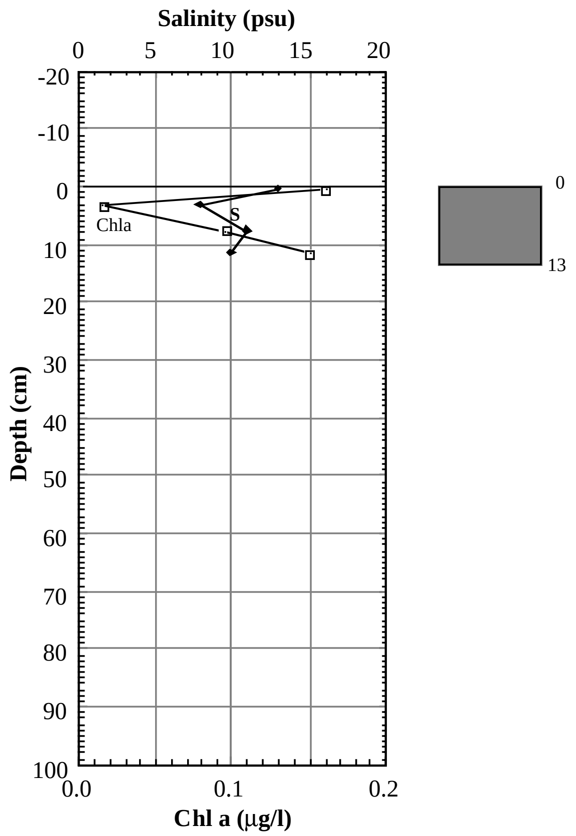
Core indicates 20 cm orbicular granular ice, with clear layers 2 - 3cm thick in the upper 5 cm.

12 June 1992: N0416411

Ship Station Number:	21/587	Air Temperature (°C):	-6.40
Time:	19:45	Snow Surf. Temperature (°C):	
Latitude:	62°00.5'S	Snow Thickness (m):	
Longitude:	00°00.2'W	Total Ice Thickness (m):	0.13
		Freeboard (m):	0.01

Notes
Pancake of 0.7 m diameter, sampled with ships crane.
Seawater salinity 34.32 psu

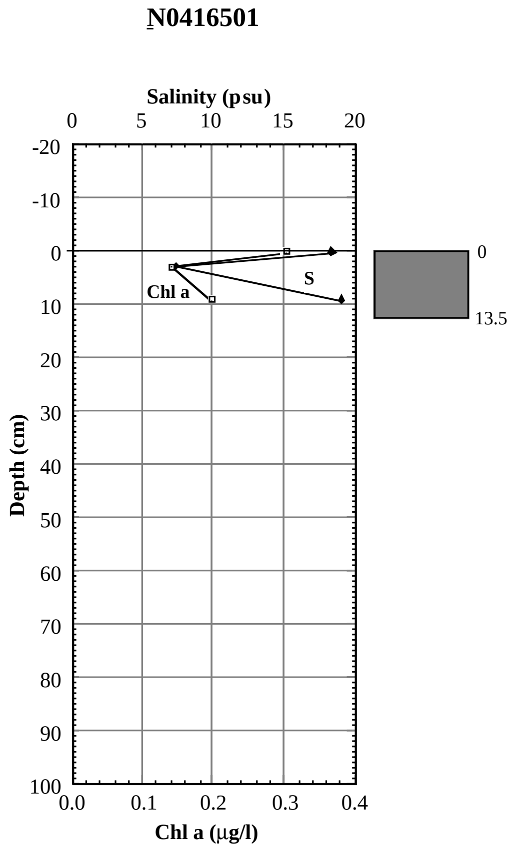
N0416411

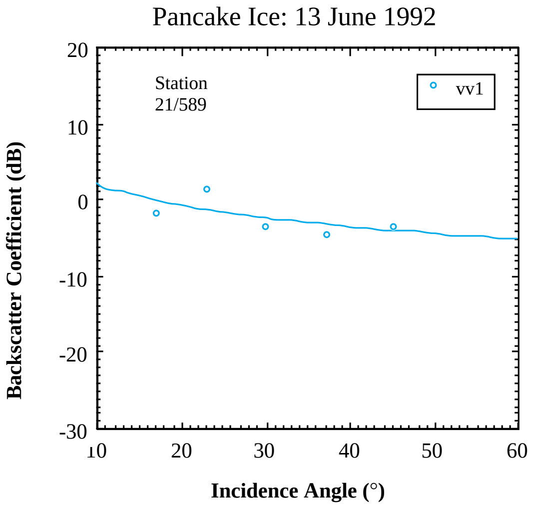


13 June 1992: N0416501

Ship Station Number:	21/589	Air Temperature (°C):	-4.70
Time:	08:10	Snow Surf. Temperature (°C):	0.00
Latitude:	63°00.2'S	Snow Thickness (m):	0.00
Longitude:	00°00.4'W	Total Ice Thickness (m):	0.14
		Freeboard (m):	0.01

Notes
Flooded pancake of 0.7 m diameter, sampled with ships crane.
Seawater salinity 34.26 psu

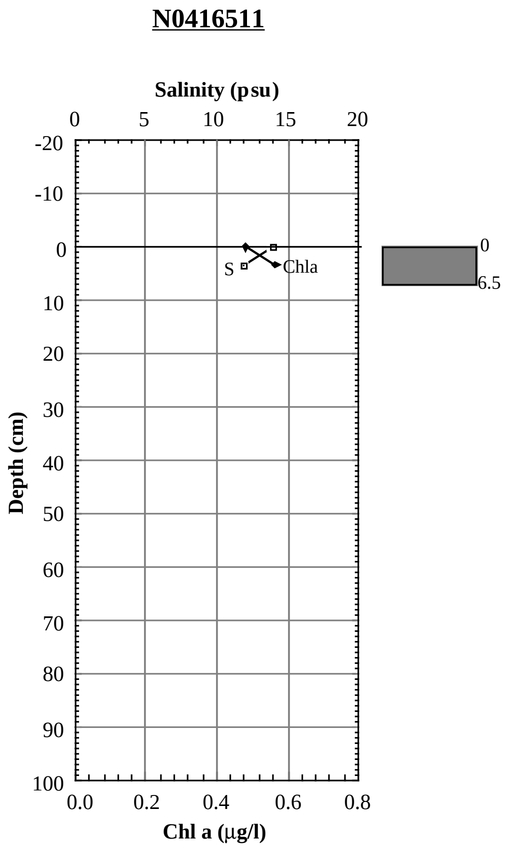




13 June 1992: N0416511

Ship Station Number:	21/590	Air Temperature (°C):	-7.10
Time:	17:06	Snow Surf. Temperature (°C):	
Latitude:	63°30.3'S	Snow Thickness (m):	0.000
Longitude:	00°00.4'E	Total Ice Thickness (m):	0.065
		Freeboard (m):	0.005

Notes
Pancake of 0.8 m diameter, sampled with ships crane.
Seawater salinity 34.26 psu.



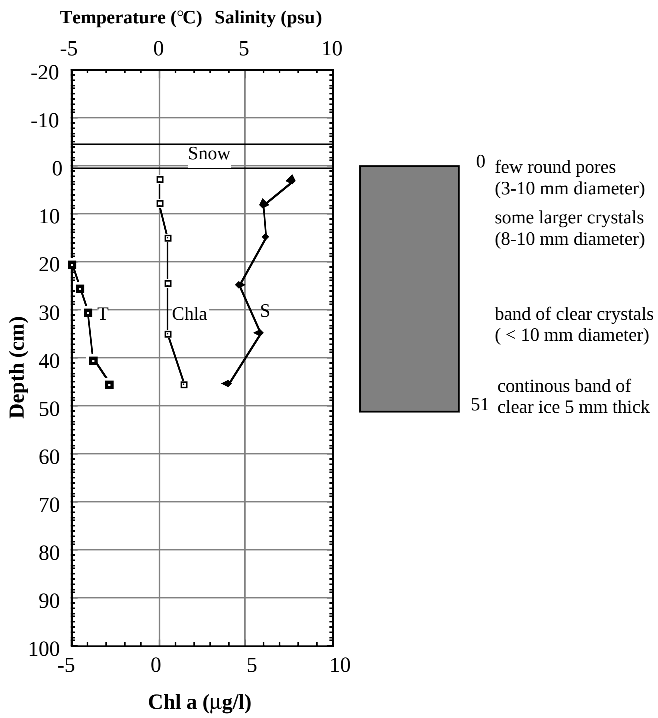
15 June 1992: N0416701

Ship Station Number:	21/596	Air Temperature (°C):	-12.50
Time:	11:27	Snow Surf. Temperature (°C):	
Latitude:	66°30.1'S	Snow Thickness (m):	0.05
Longitude:	00°00.9'E	Total Ice Thickness (m):	0.51
		Freeboard (m):	0.08

Notes

Coring of a floe, 15 m in diameter, composed of pancakes. Obviously rafted at coring site.
Snow Salinity 3.2 psu
Seawater salinity 34.53 psu

N0416701



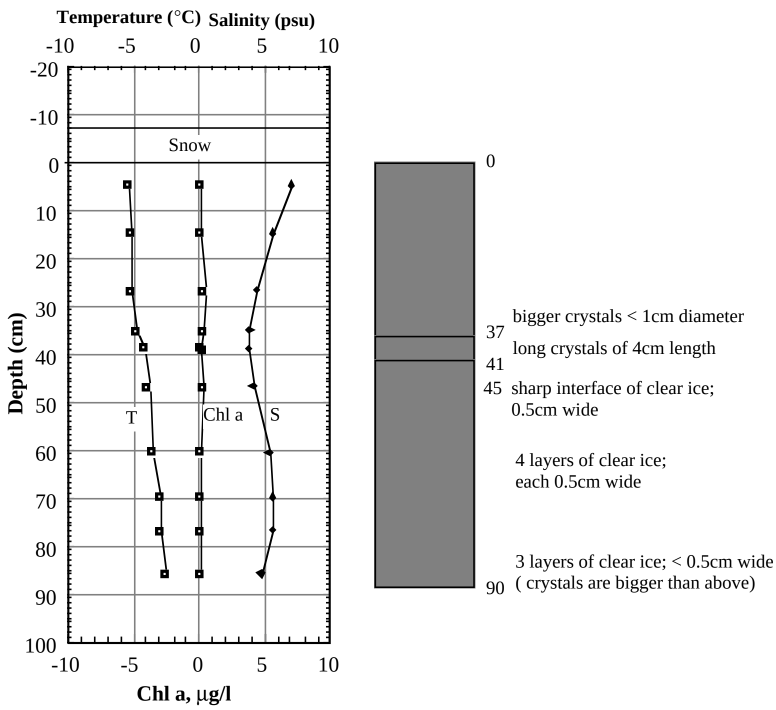
16 June 1992: N0416801

Ship Station Number:	21/598	Air Temperature (°C):	-13.90
Time:	06:16	Snow Surf. Temperature (°C):	
Latitude:	67°30.2'S	Snow Thickness (m):	0.07
Longitude:	00°00.4'E	Total Ice Thickness (m):	0.90
		Freeboard (m):	0.07

Notes

Floe of 3 m diameter, sampled with mummychair.
Obviously rafted (by the ship?) between 60 and 65 cm.
Seawater Salinity 34.54 psu

N0416801

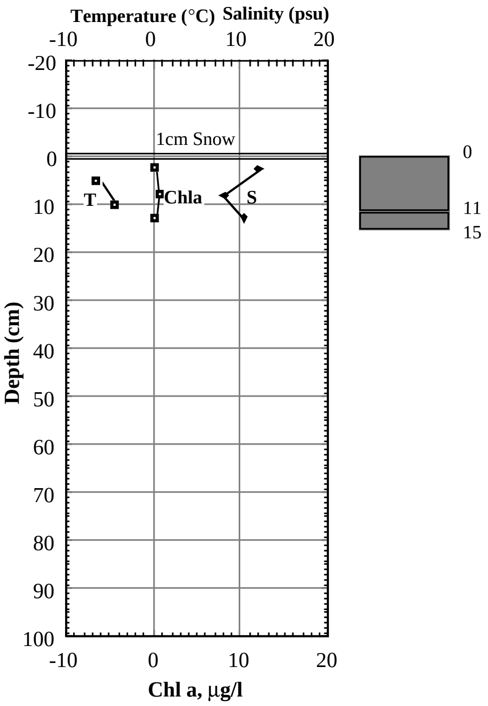


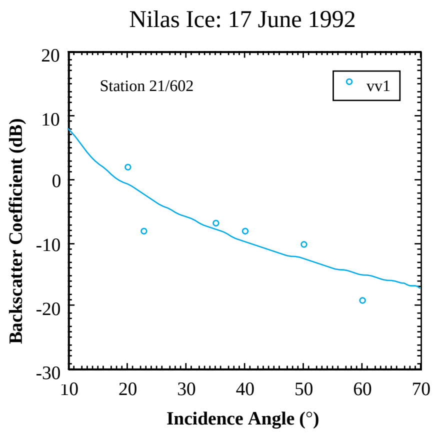
17 June 1992: N0416901

Ship Station Number:	21/602	Air Temperature (°C):	-21.50
Time:	12:03	Snow Surf. Temperature (°C):	
Latitude:	68°44.7'S	Snow Thickness (m):	0.01
Longitude:	00°01.5'E	Total Ice Thickness (m):	0.15
		Freeboard (m):	0.005

Notes
Sampling of light nilas with mummy chair.
Bulk snow salinity of 47.8 psu
Seawater Salinity 34.5 psu
Look also at 16903.

N0416901





17 June 1992: N0416903

Ship Station Number:	21/602	Air Temperature (°C):	-21.50
Time:	12:03	Snow Surf. Temperature (°C):	-9.70
Latitude:	68°44.7'S	Snow Thickness (m):	0.40
Longitude:	00°01.5'E	Total Ice Thickness (m):	> 3.00
		Freeboard (m):	high

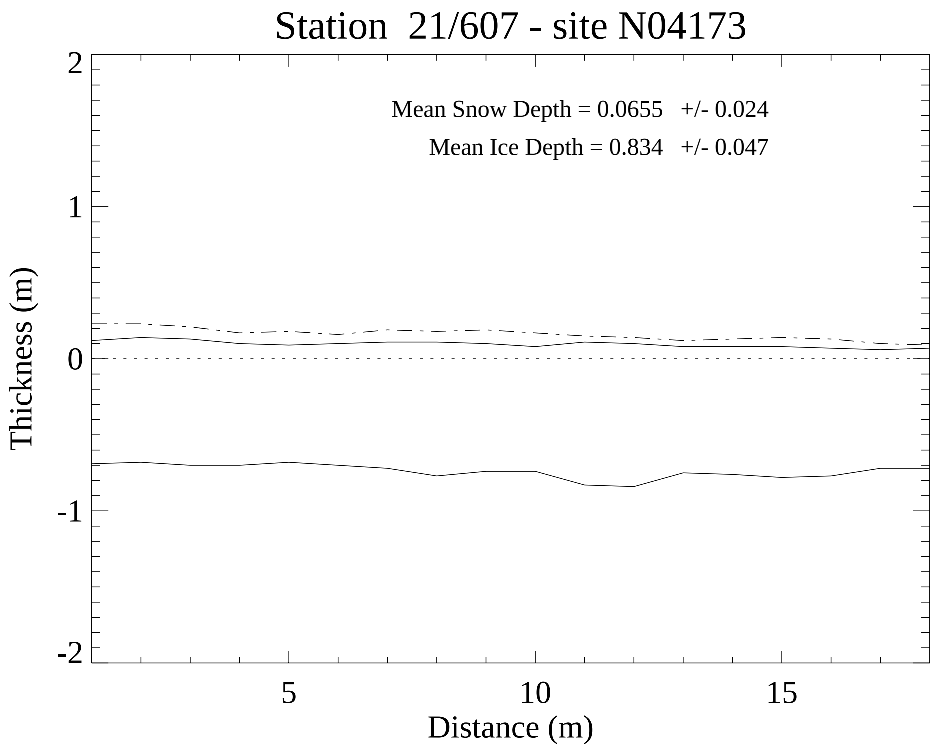
Notes
Floe of 12 m diameter, with high freeboard and thickness > 3 m.
Probably old fast ice.
Snow thickness profile and snow sampling.
Seawater Salinity 34.5 psu
No core because of motor trouble.

21 June 1992: N0417301

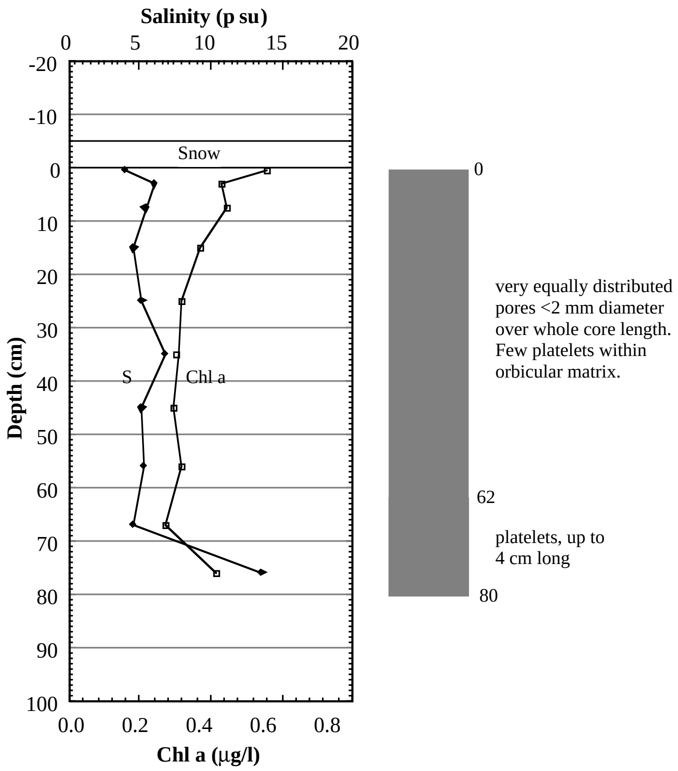
Ship Station Number:	21/607	Air Temperature (°C):	-13.20
Time:	08:48	Snow Surf. Temperature (°C):	
Latitude:	70°32.3'S	Snow Thickness (m):	0.02
Longitude:	08°02.1'W	Total Ice Thickness (m):	0.79
		Freeboard (m):	0.07

Notes
Station in Atka Bay on undeformed new ice (snow deposited in ships lee).
Coresite at point 17 of thickness profile 1. No temperature profile obtained.
Laser profilometer some 30 m apart.
Few platelets embedded in the orbicular part.
Seawater Salinity 34.70 psu

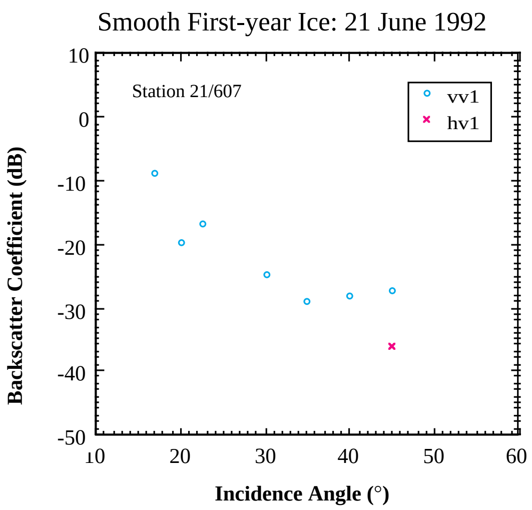
Thickness Profile Data



N0417301



Salinity (p su)
0
5
10
15
20
-20
-10
0
10
20
30
40
50
60
70
80
90
100
Snow
S
Chl a
Depth (cm)
0.0
0.2
0.4
0.6
0.8
Chl a (µg/l)
0
62
80
very equally distributed pores <2 mm diameter over whole core length. Few platelets within orbicular matrix.
platelets, up to 4 cm long



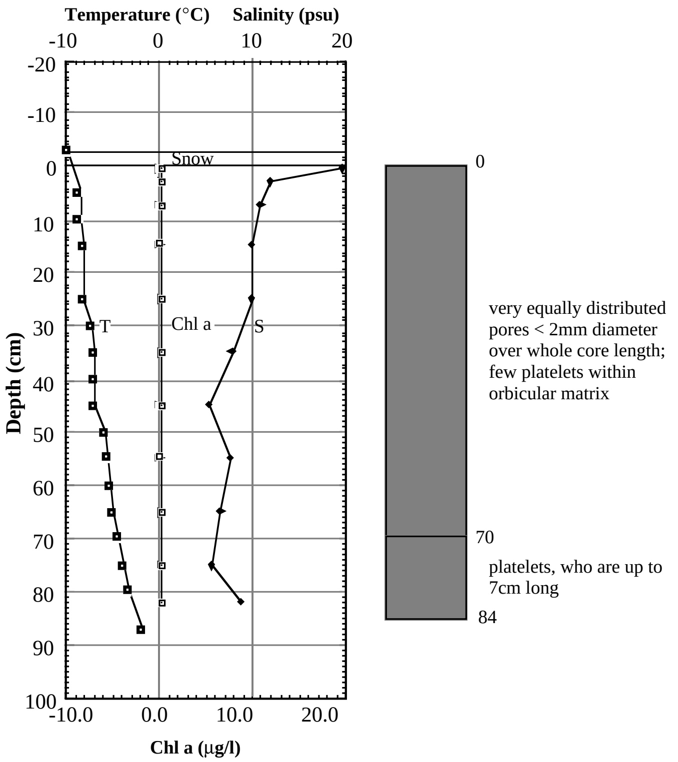
Smooth First-year Ice: 21 June 1992
Station 21/607
vv1
hv1
Backscatter Coefficient (dB)
10
0
-10
-20
-30
-40
-50
10
20
30
40
50
60
Incidence Angle (°)

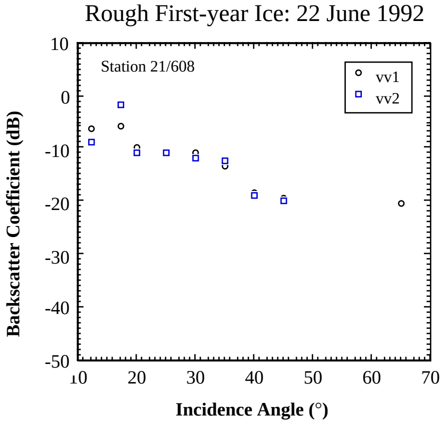
22 June 1992: N0417401

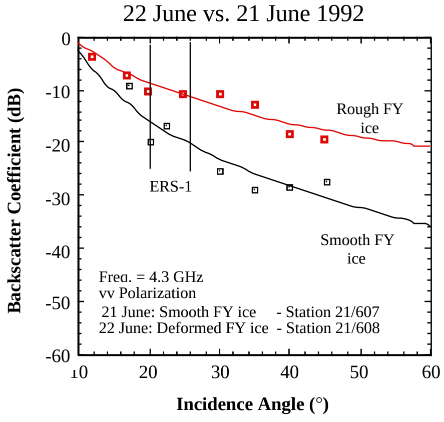
Ship Station Number:	21/607	Air Temperature (°C):	-13.50
Time:	08:48	Snow Surf. Temperature (°C):	
Latitude:	70°32.3'S	Snow Thickness (m):	0.02
Longitude:	08°02.1'W	Total Ice Thickness (m):	0.84
		Freeboard (m):	0.06

Notes
Coring site within 15 m of that of previous day 173.
Snow sampling and snow thickness profile.
Few platelets embedded in orbicular part.
Snow salinity 9.12 psu
Note that radar scans were made before and after overnight ridging.
The lower right figure compares radar data on 21 and 22 June, 1992.

N0417401





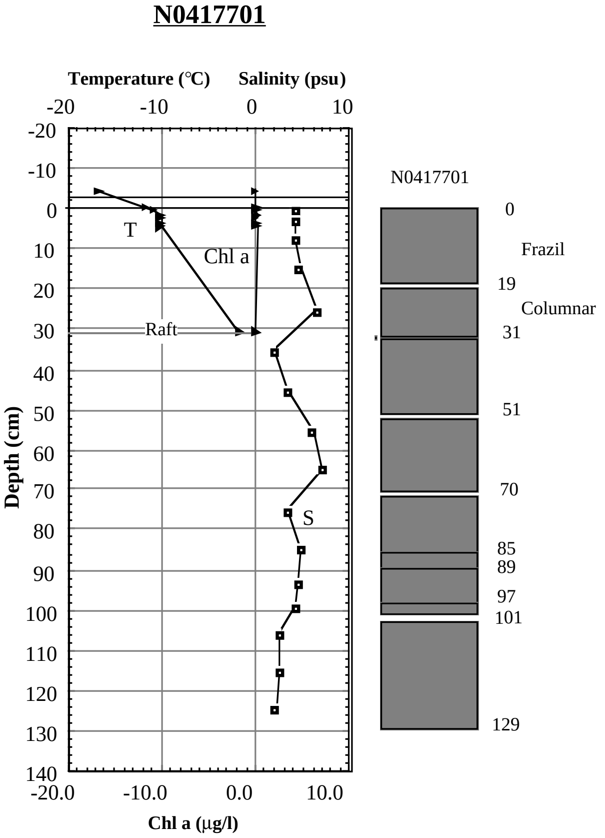


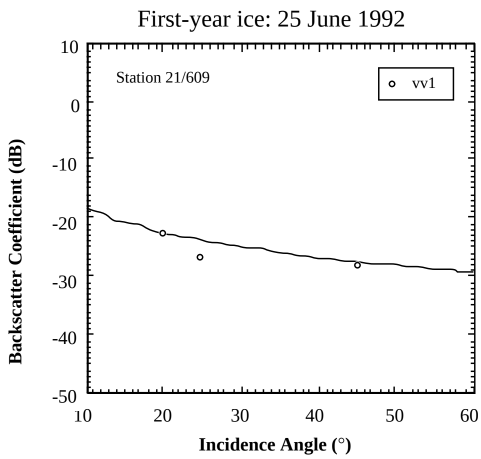
25 June 1992: N0417701

Ship Station Number:	21/609	Air Temperature (°C):	-17.60
Time:	14:30	Snow Surf. Temperature (°C):	
Latitude:	70°27.5'S	Snow Thickness (m):	0.03
Longitude:	08°31.8'W	Total Ice Thickness (m):	> 5.00
		Freeboard (m):	0.90

Notes
Very heavily deformed pack ice. Sampling site of 15 m diameter, surrounded by 2-3 m high ridges. Sampled core is composed of at lest four rafted parts, 31, 20, 19 and 31 cm thick, with gaps of slush/platelets of undetermined thickness inbetween.

Coring length > 2.5 m. Ice thickness > 5 m, with partially consolidated slush/platelets in the lower parts. From 70-129 cm brine loss and redistribution due to sampling problems.

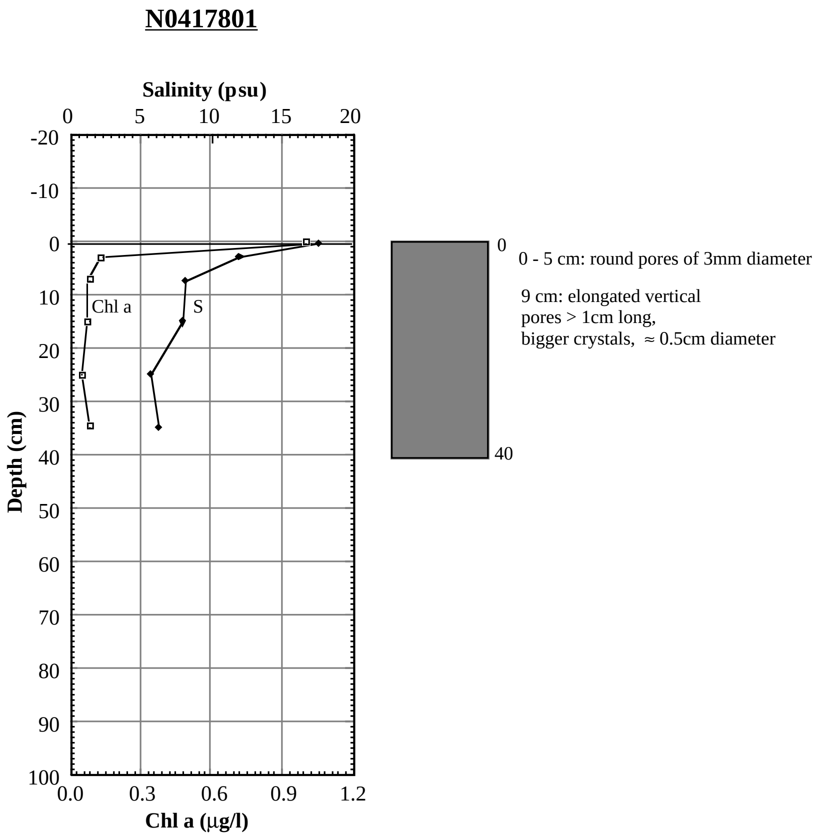




26 June 1992: N0417801

Ship Station Number:	21/609	Air Temperature (°C):	-23.00
Time:	14:30	Snow Surf. Temperature (°C):	
Latitude:	70°27.5'S	Snow Thickness (m):	0.07
Longitude:	08°31.8'W	Total Ice Thickness (m):	0.40
		Freeboard (m):	0.05

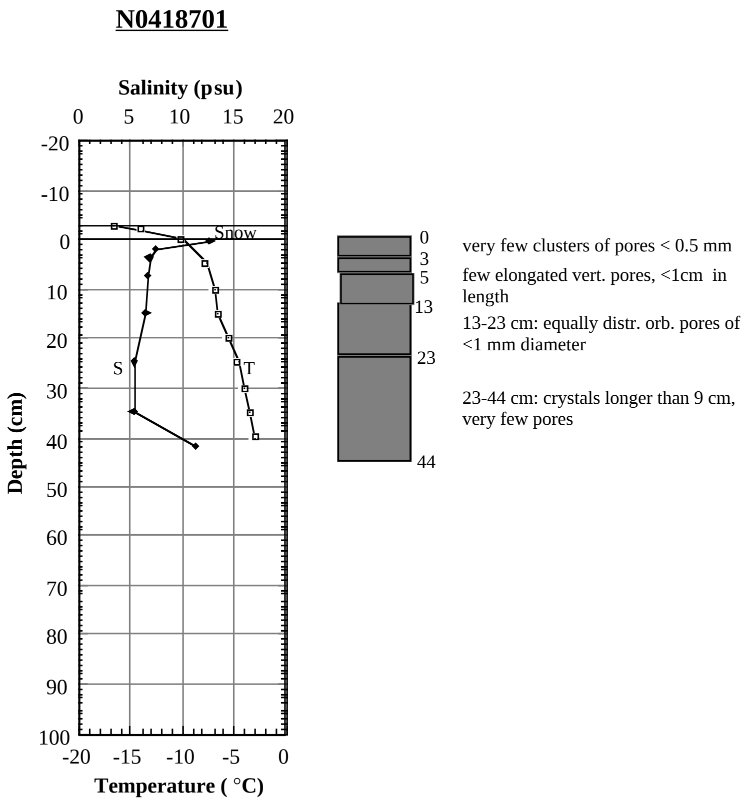
Notes
Level floe of >200 m diameter, surrounded by flat ridges, 200 m ahead the ship.
Core site at point 1 of randomly distributed thickness soundings 178r.



5 July 1992: N0418701

Ship Station Number:	21/614	Air Temperature (°C):	-16.60
Time:	13:00	Snow Surf. Temperature (°C):	-14.00
Latitude:	71°38.0'S	Snow Thickness (m):	0.02
Longitude:	16°35.0'W	Total Ice Thickness (m):	0.44
		Freeboard (m):	0.04

Notes
Flat floe (100 m diameter) within heavy pressed ice pack (raised ice blocks with brown undersides), reached by the helicopter.
Site of SAR-Reflector. Snowsampling, Permeability measurement.
Permeability Core 187perm, several cores for silicate measurements.
Temperature Snow/Ice Int. -10°C



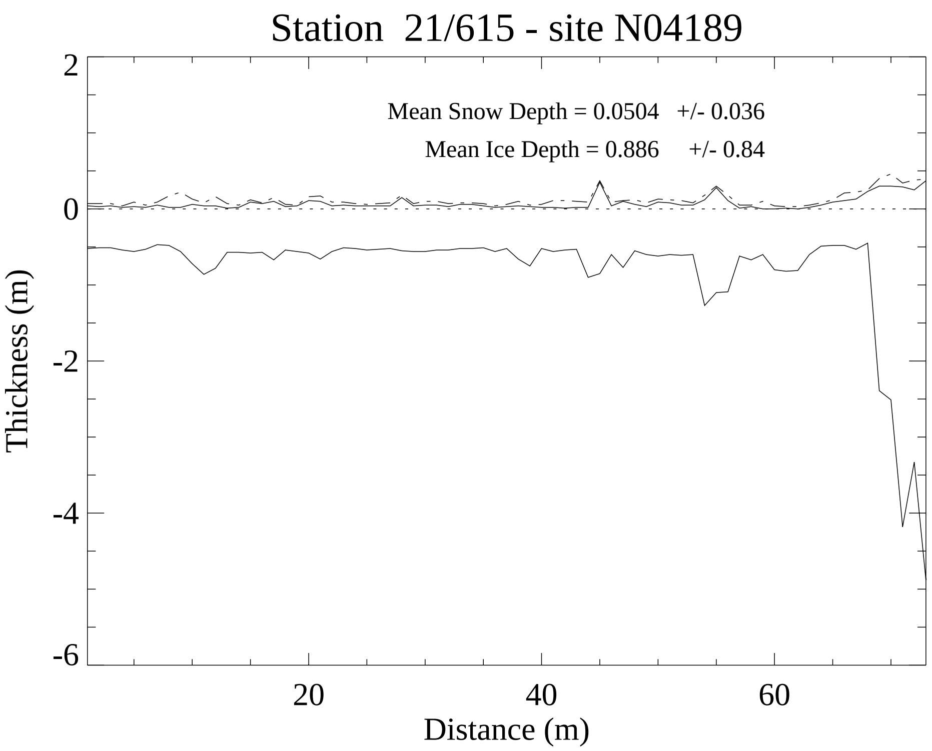
7 July 1992: N0418901

Ship Station Number:	21/615	Air Temperature (°C):	-6.90
Time:	09:45	Snow Surf. Temperature (°C):	-6.70
Latitude:	72°03.0'S	Snow Thickness (m):	0.03
Longitude:	18°06.6'W	Total Ice Thickness (m):	0.54
		Freeboard (m):	0.03

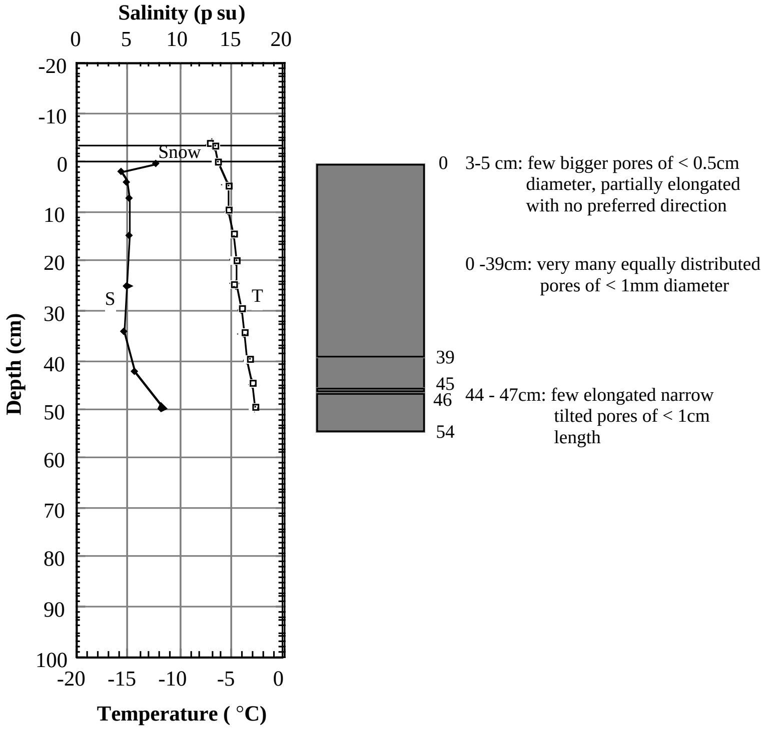
Notes

Coring on hummocked floe (stoney field) of several 100 m diameter, surrounded by heavy pressed ice with up to 5 m high ridges.
Coring site near point 0 of thickness profile.
Laser profilometer some 30 m apart.
Permeability core.
Snow sampling and thickness measurements.
Permeability measurement.
Snow/ice-interface temperature -6.4°C

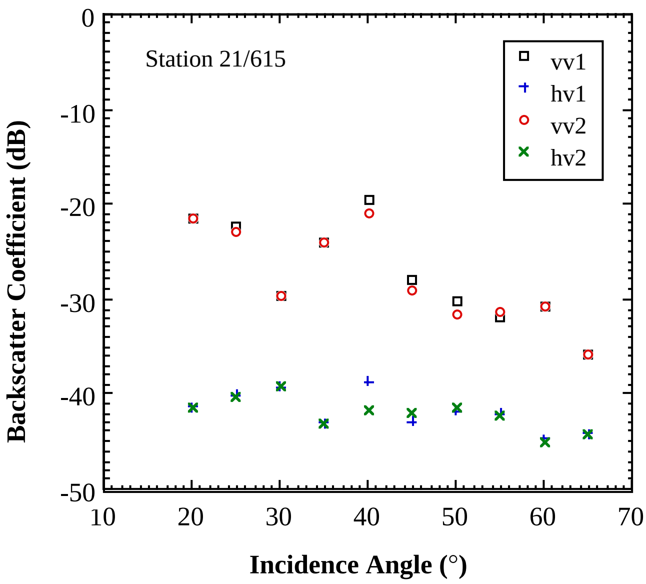
Thickness Profile Data



N0418901



White Ice: 7 July 1992

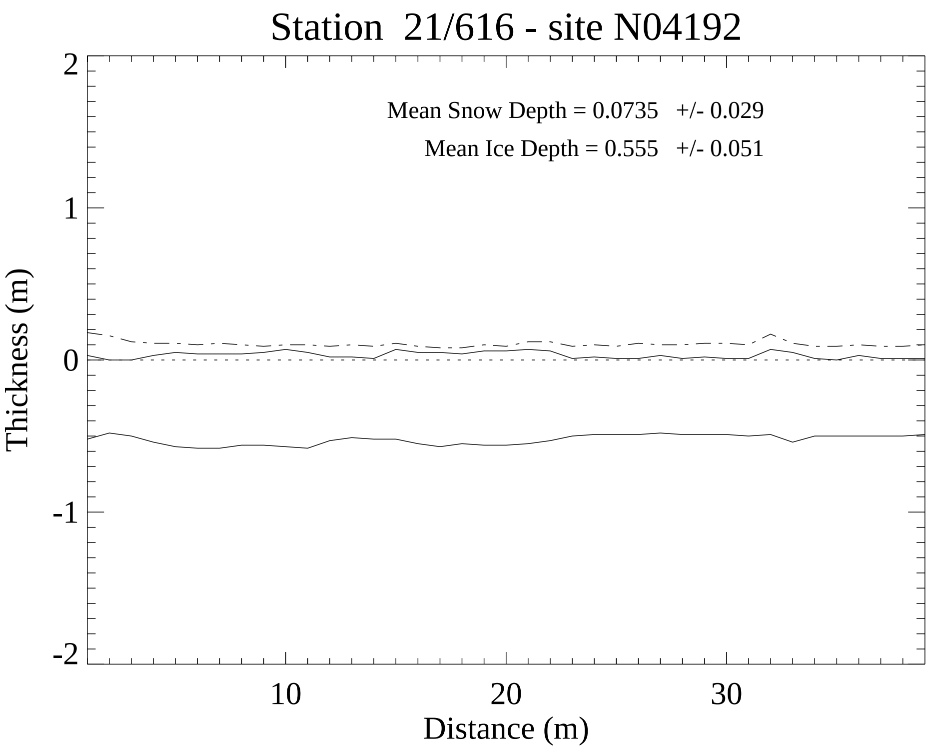


10 July 1992: N0419201

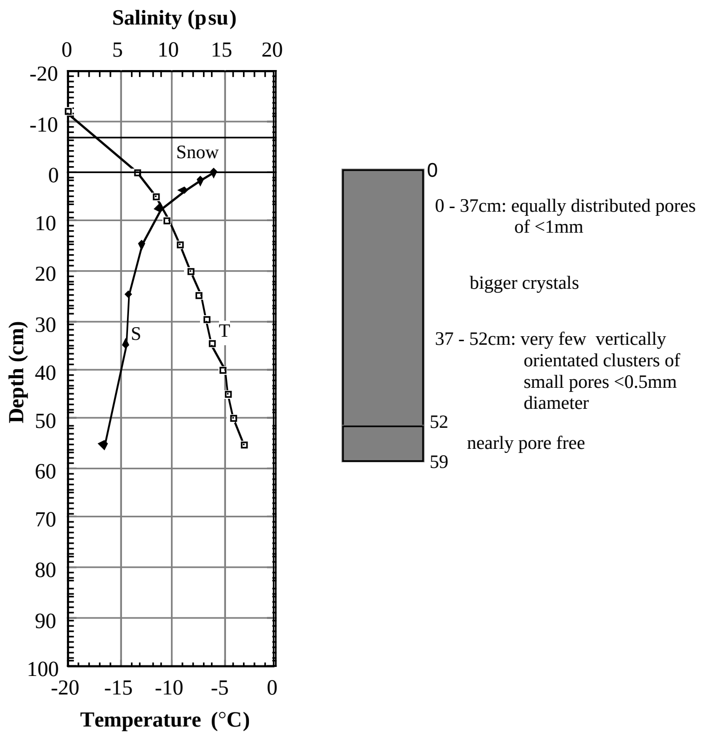
Ship Station Number:	21/616	Air Temperature (°C):	-23.60
Time:	6:00	Snow Surf. Temperature (°C):	-22.40
Latitude:	69°44.1'S	Snow Thickness (m):	0.12
Longitude:	23°46.7'W	Total Ice Thickness (m):	0.59
		Freeboard (m):	0.035

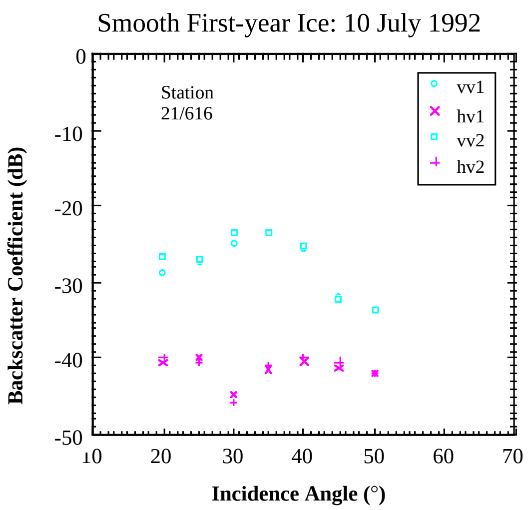
Notes
Flat and very homogenous floe.
Coring site near 0 m in thickness profile,
and 20 m apart from deployment of Argos buoy.
Archive Core.
Permeability measurement, snow sampling and characterisation.

Thickness Profile Data



N0419201





10 July 1992: N0419211

Ship Station Number:	21/619	Air Temperature (°C):	-26.30
Time:	24:00	Snow Surf. Temperature (°C):	
Latitude:	68°58.7'S	Snow Thickness (m):	0.01
Longitude:	25°41.5'W	Total Ice Thickness (m):	0.48
		Freeboard (m):	

Notes
Core from SAR-reflector deployment on flat firstyear ice.

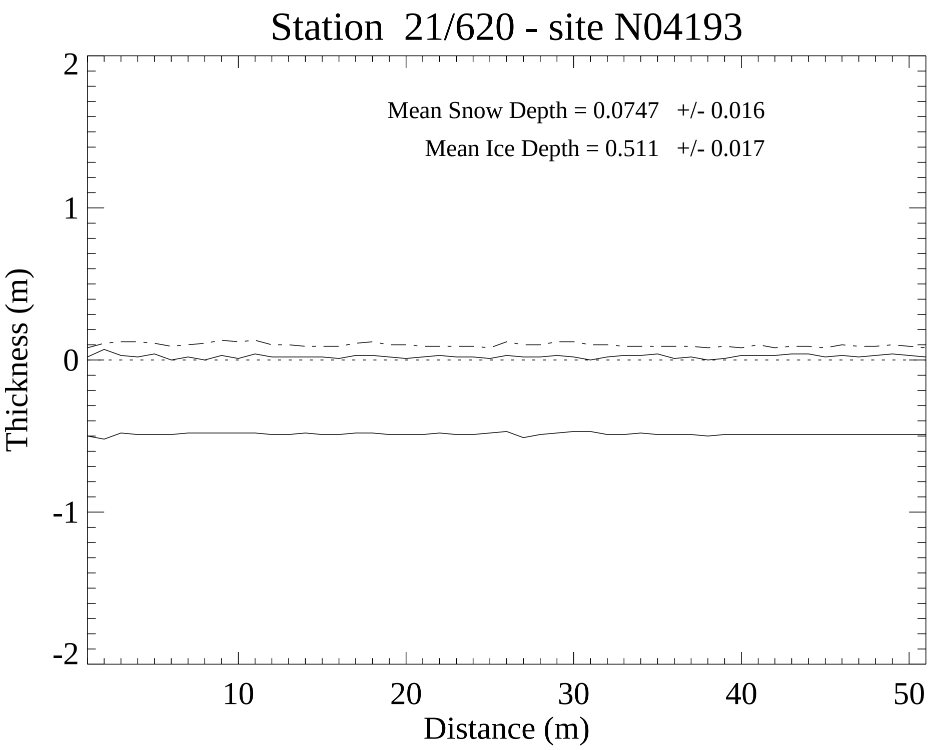
Only texture and salinity were determined.

11 July 1992: N0419301

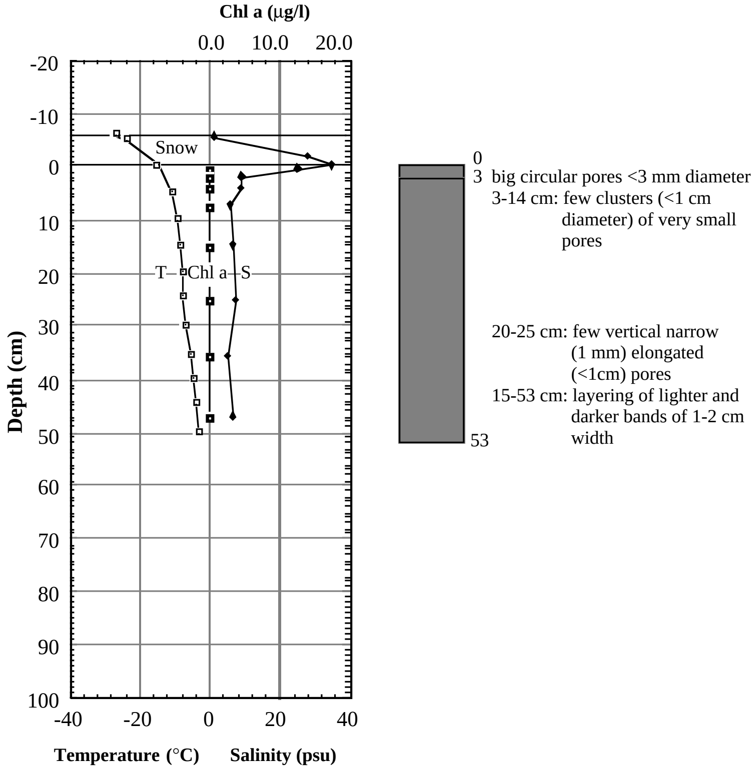
Ship Station Number:	21/620	Air Temperature (°C):	-27.40
Time:	05:32	Snow Surf. Temperature (°C):	-24.10
Latitude:	68°44.3'S	Snow Thickness (m):	0.05
Longitude:	26°18.8'W	Total Ice Thickness (m):	0.53
		Freeboard (m):	0.025

Notes
Very flat, homogenous vast floe. Coring site appr. 30 m apart from Argos buoy deployment. 50 m thickness profile.
Permeability measurement. Snow sampling and characterisation.
Archive Core

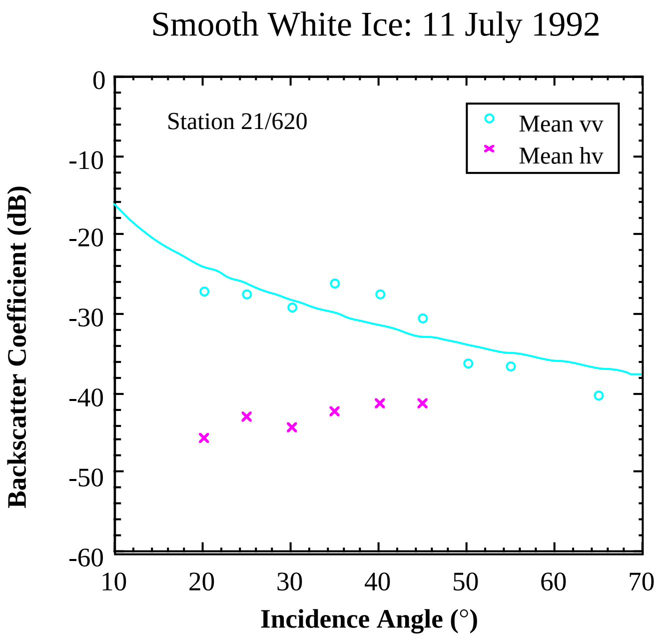
Thickness Profile Data



N0419301



Chl a (µg/l)
0.0
10.0
20.0
-20
-10
0
10
20
30
40
50
60
70
80
90
100
Snow
T
Chl a
S
Depth (cm)
-40
-20
0
20
40
Temperature (°C)
Salinity (psu)
0
3
53
big circular pores <3 mm diameter
3-14 cm: few clusters (<1 cm diameter) of very small pores
20-25 cm: few vertical narrow (1 mm) elongated (<1cm) pores
15-53 cm: layering of lighter and darker bands of 1-2 cm width



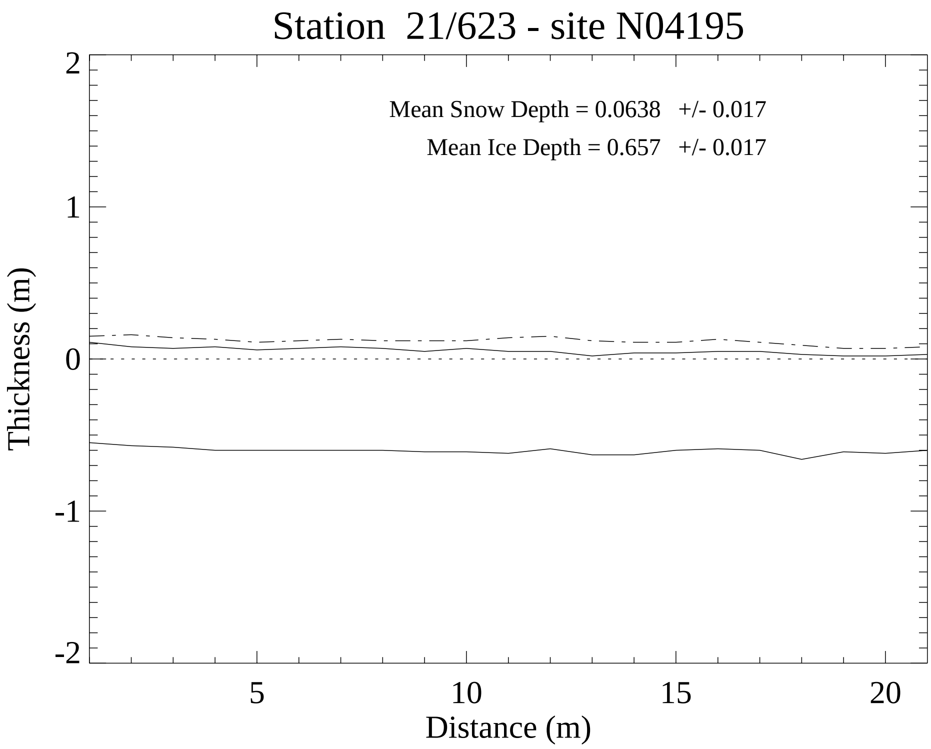
Smooth White Ice: 11 July 1992
Station 21/620
Mean vv
Mean hv
Backscatter Coefficient (dB)
0
-10
-20
-30
-40
-50
-60
10
20
30
40
50
60
70
Incidence Angle (°)

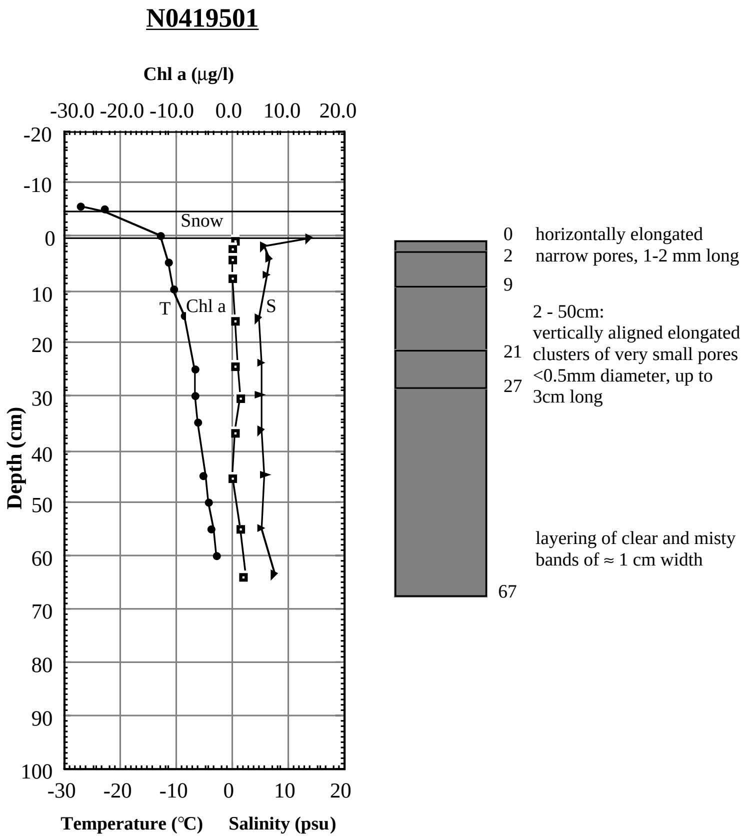
13 July 1992: N0419501

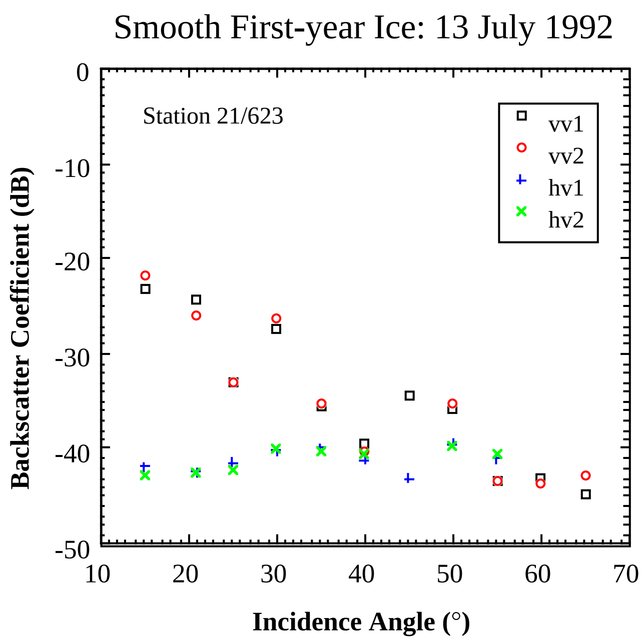
Ship Station Number:	21/623	Air Temperature (°C):	-27.00
Time:	14:30	Snow Surf. Temperature (°C):	-22.80
Latitude:	65°59.4'S	Snow Thickness (m):	0.05
Longitude:	33°29.8'W	Total Ice Thickness (m):	0.67
		Freeboard (m):	0.03

Notes
Coring on vast flat uniform floe, near point 13 along the thickness profile.

Thickness Profile Data




N0419501
Chl a (µg/l)
-30.0 -20.0 -10.0 0.0 10.0 20.0
Snow
T
Chl a
S
Depth (cm)
Temperature (°C)
Salinity (psu)
0
2
9
21
27
67
horizontally elongated narrow pores, 1-2 mm long
2 - 50cm:
vertically aligned elongated clusters of very small pores <0.5mm diameter, up to 3cm long
layering of clear and misty bands of ≈ 1 cm width

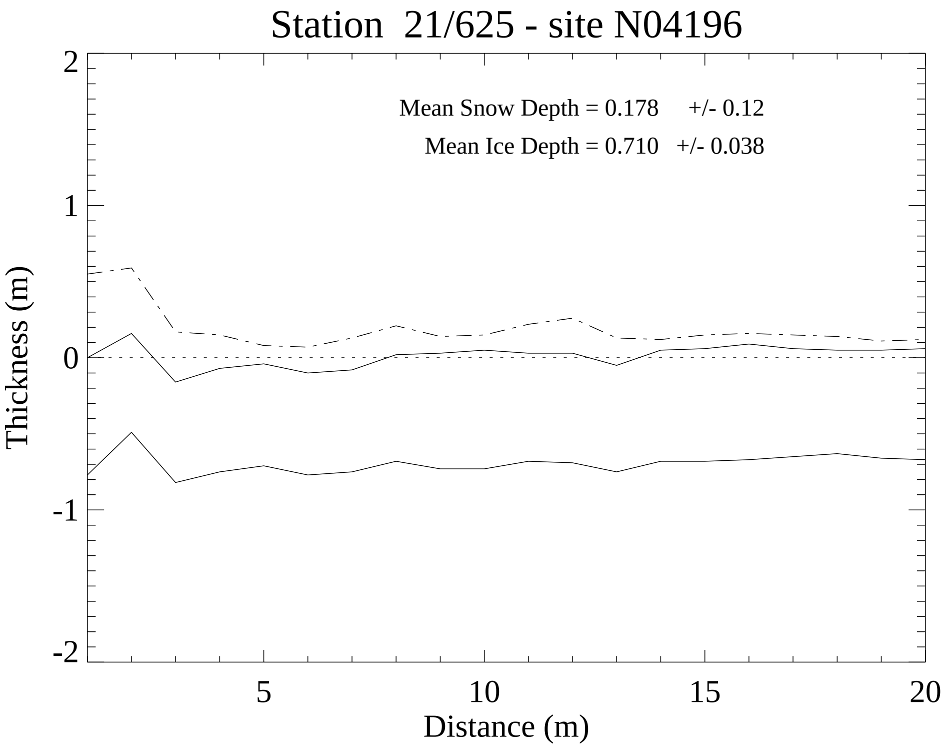

Smooth First-year Ice: 13 July 1992
Station 21/623
vv1
vv2
hv1
hv2
Backscatter Coefficient (dB)
Incidence Angle (°)

14 July 1992: N0419601

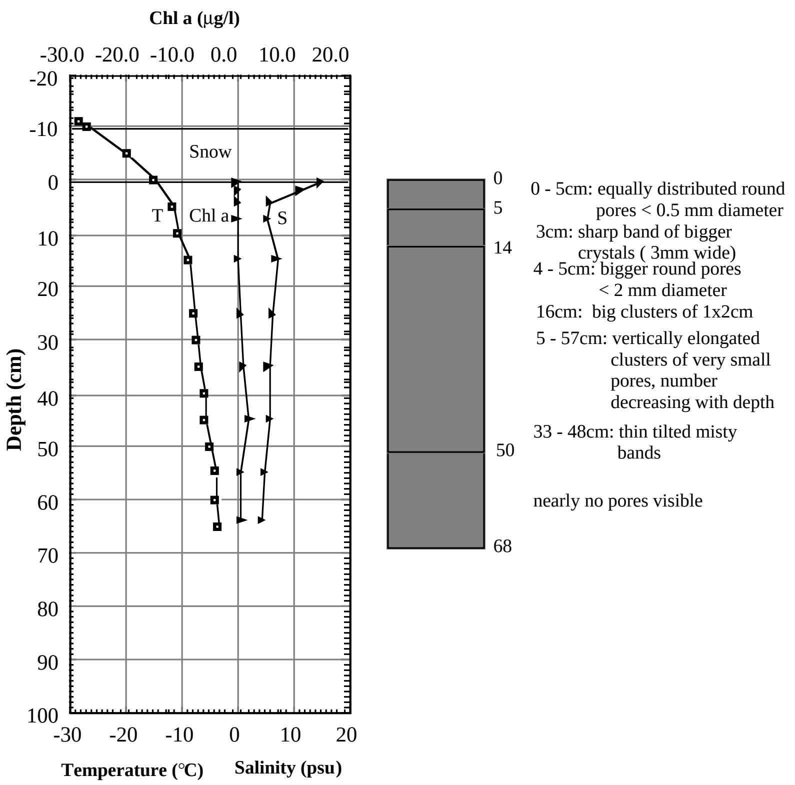
Ship Station Number:	21/625	Air Temperature (°C):	-27.80
Time:	19:05	Snow Surf. Temperature (°C):	-26.50
Latitude:	65°35.1'S	Snow Thickness (m):	0.10
Longitude:	36°27.1'W	Total Ice Thickness (m):	0.68
		Freeboard (m):	0.04

Notes
Coring on flat firstyear floe near a point 16 along the thickness profile.
Archive Core

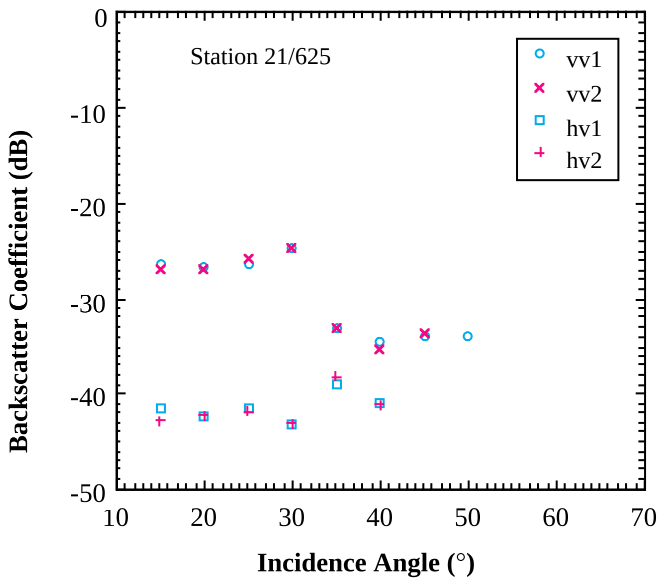
Thickness Profile Data



N0419601



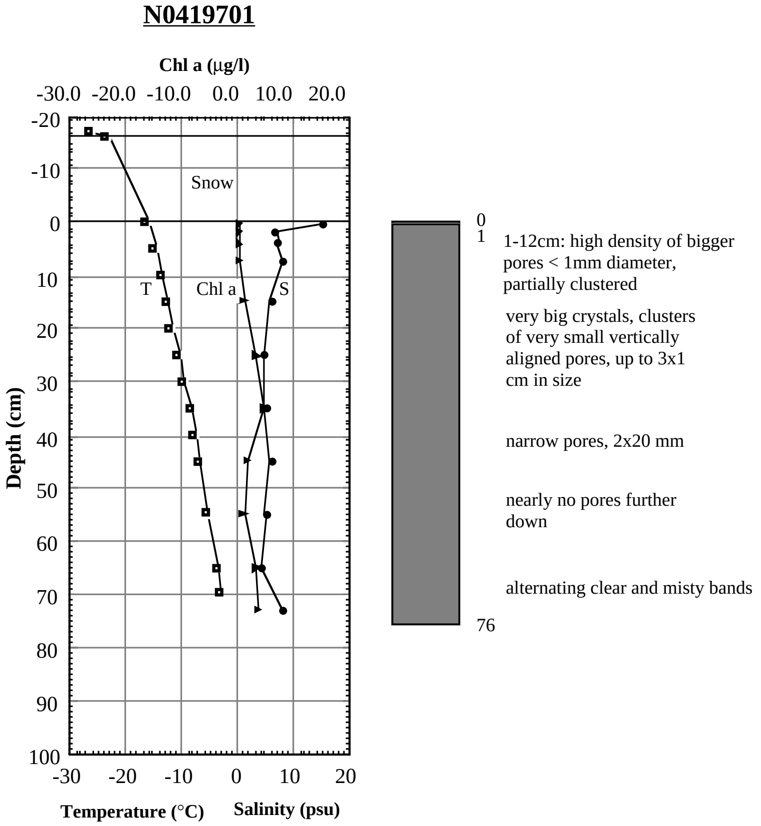
First-year Ice : 14 July 1992

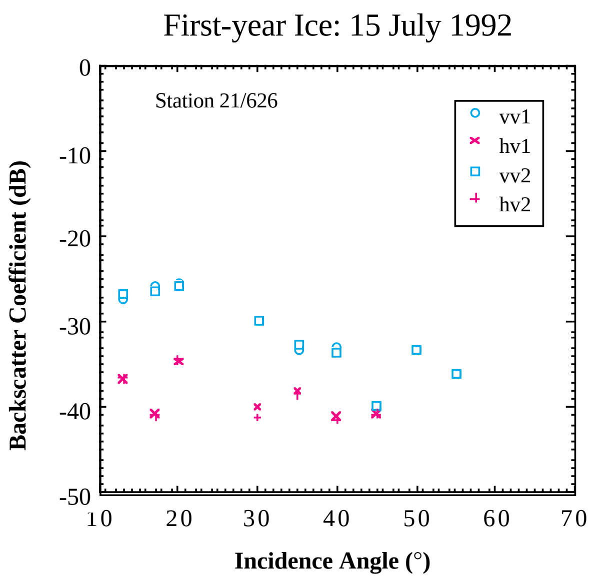


15 July 1992: N0419701

Ship Station Number:	21/626	Air Temperature (°C):	-26.10
Time:	13:12	Snow Surf. Temperature (°C):	-23.00
Latitude:	65°17.2'S	Snow Thickness (m):	0.16
Longitude:	37°40.6'W	Total Ice Thickness (m):	0.76
		Freeboard (m):	0.01

Notes
Coring on flat floe with few flat hummocks and very hard snowdrift.
Archive Core

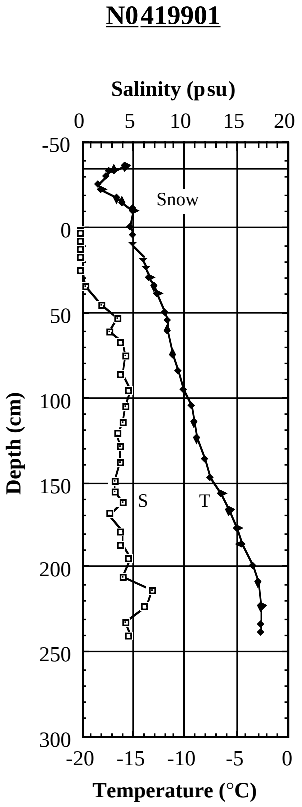


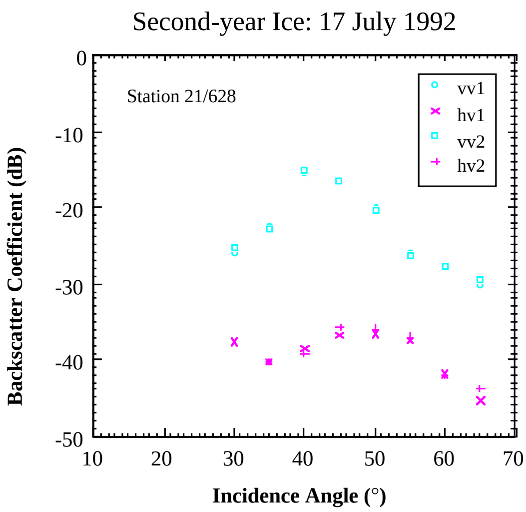


17 July 1992: N0419901

Ship Station Number:	21/628	Air Temperature (°C):	-18.10
Time:	14:21	Snow Surf. Temperature (°C):	-14.90
Latitude:	64°56.0'S	Snow Thickness (m):	0.09
Longitude:	41°20.3'W	Total Ice Thickness (m):	2.41
		Freeboard (m):	0.45

Notes
Coring on flat multiyear floe, obviously rafted at 2.2 m depth.
Random thickness measurements.
During Station time temperatures increased to -10°C.



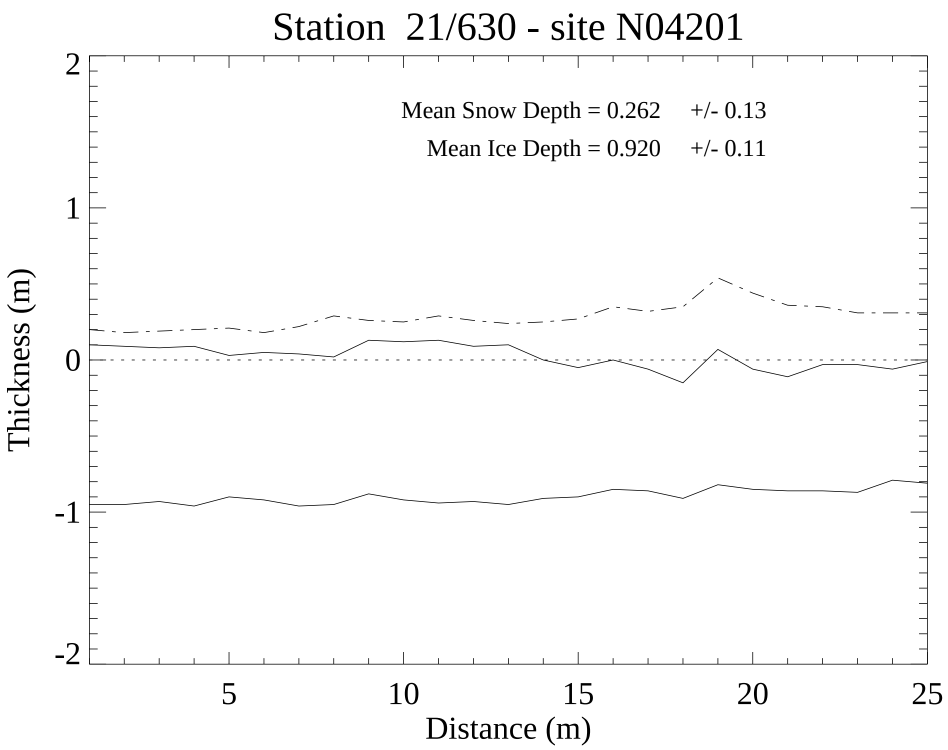


19 July 1992: N0420101

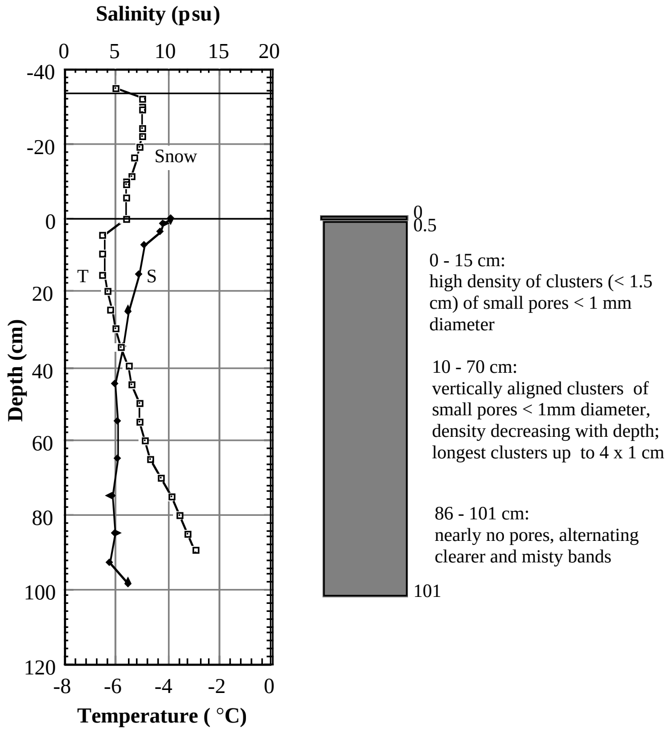
Ship Station Number:	21/630	Air Temperature (°C):	-5.10
Time:	07:12	Snow Surf. Temperature (°C):	-5.60
Latitude:	63°43.5'S	Snow Thickness (m):	0.35
Longitude:	43°24.5'W	Total Ice Thickness (m):	1.01
		Freeboard (m):	0.10

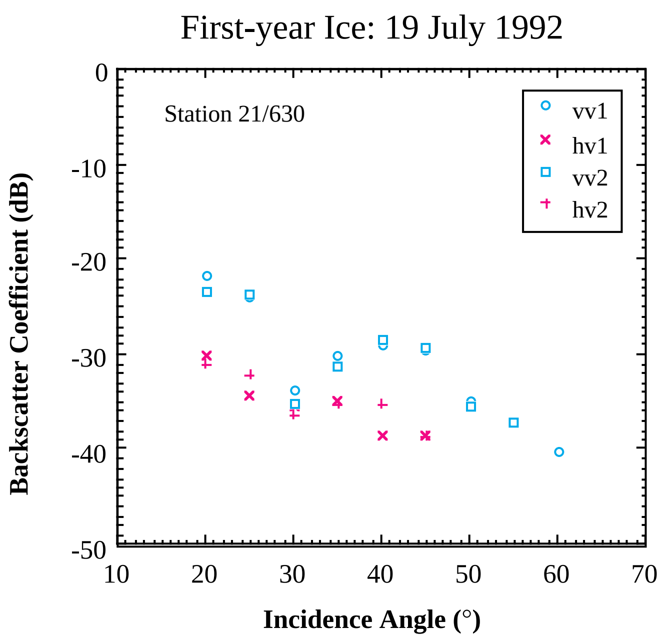
Notes
Coring on hummocked (<1 m) floe
near point 1 of 50 m thickness profile.
2 archive cores
Permeability measurement

Thickness Profile Data



N0420101


Salinity (psu)
0 5 10 15 20
-40
-20
0
20
40
60
80
100
120
Snow
T
S
Depth (cm)
-8 -6 -4 -2 0
Temperature (°C)
0
0.5
0 - 15 cm:
high density of clusters (< 1.5 cm) of small pores < 1 mm diameter
10 - 70 cm:
vertically aligned clusters of small pores < 1mm diameter, density decreasing with depth; longest clusters up to 4 x 1 cm
86 - 101 cm:
nearly no pores, alternating clearer and misty bands
101

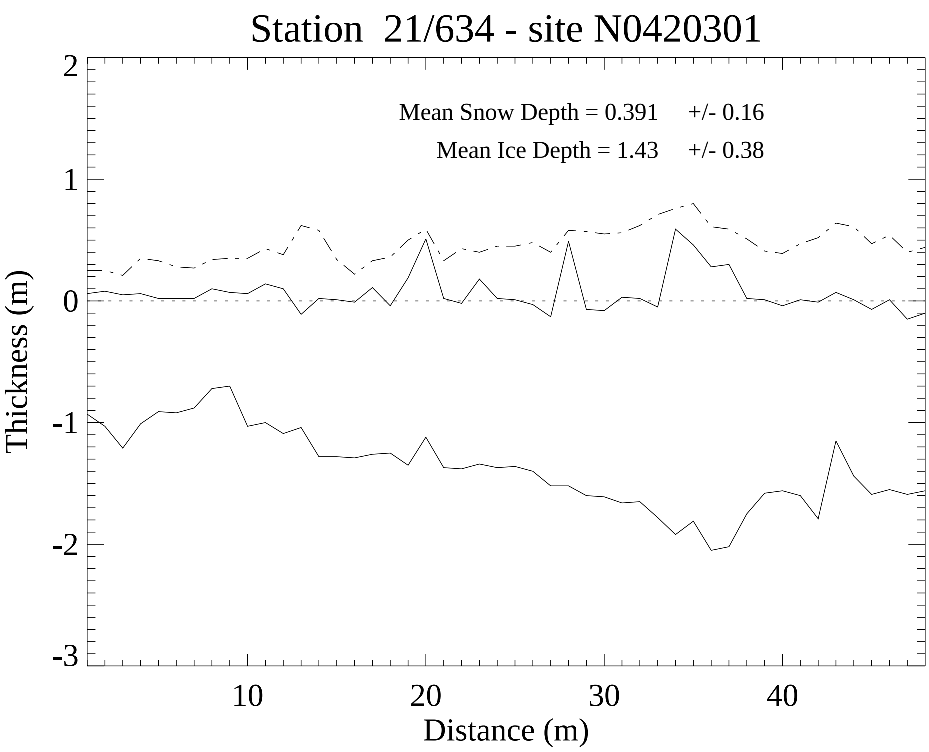

First-year Ice: 19 July 1992
Station 21/630
vv1
hv1
vv2
hv2
0
-10
-20
-30
-40
-50
Backscatter Coefficient (dB)
10 20 30 40 50 60 70
Incidence Angle (°)

21 July 1992: N0420301

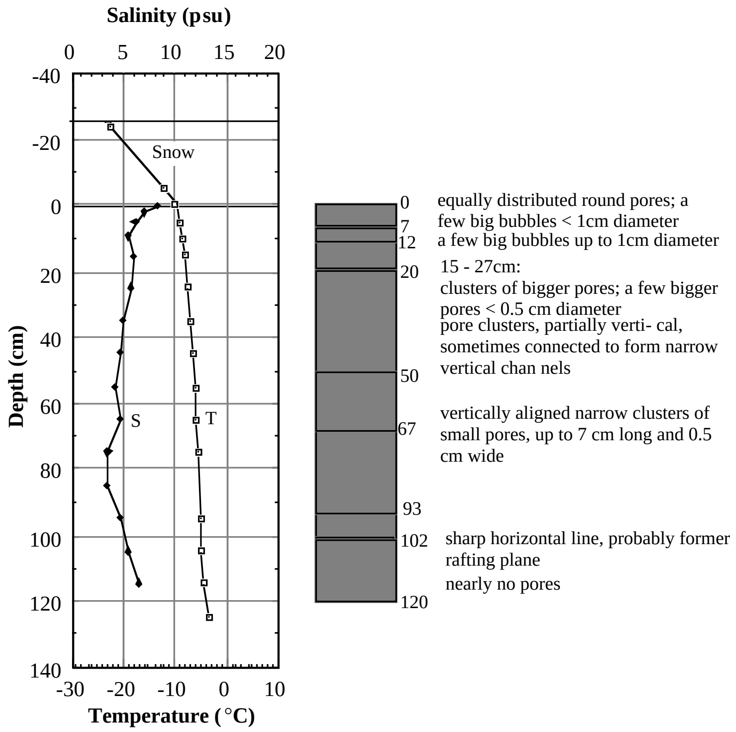
Ship Station Number:	21/634	Air Temperature (°C):	-23.30
Time:	07:21	Snow Surf. Temperature (°C):	-22.60
Latitude:	62°20.5'S	Snow Thickness (m):	0.24
Longitude:	43°41.1'W	Total Ice Thickness (m):	1.20
		Freeboard (m):	0.15

Notes:
Coring on floe with smooth but high hummocks
and variable snowcover near 32 m of thickness profile N0420301.

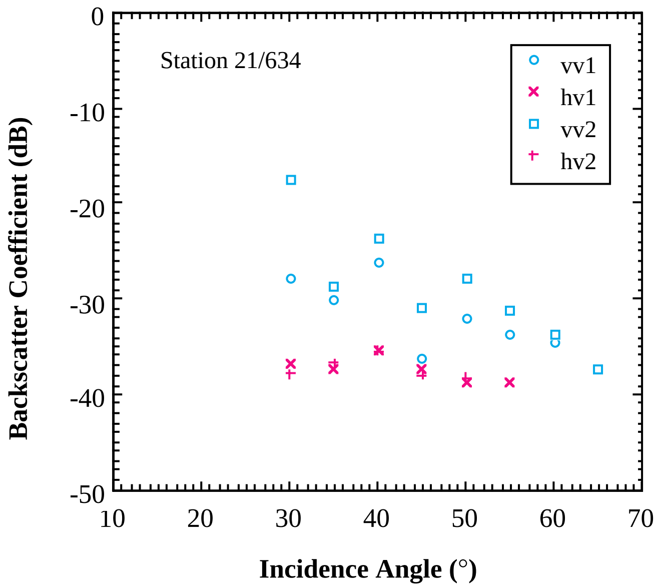
Thickness Profile Data



N0420301



Rough First-year ice: 21 July 1992

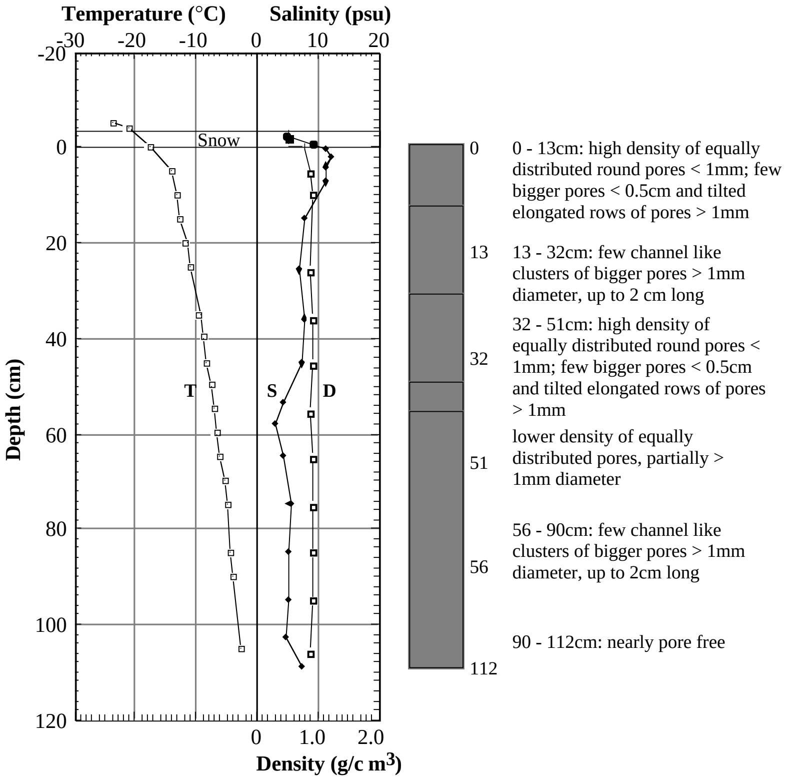


21 July 1992: N0420311

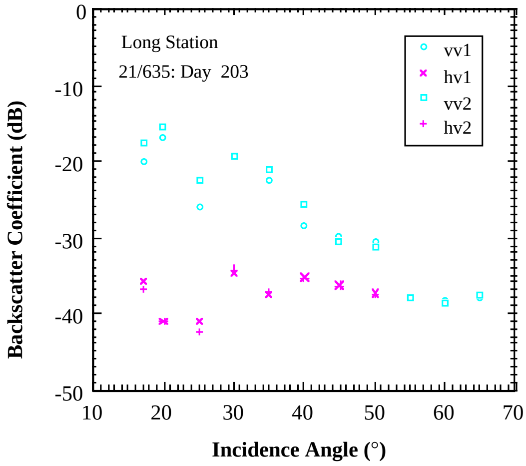
Ship Station Number:	21/635	Air Temperature (°C):	-23.70
Time:	19:00	Snow Surf. Temperature (°C):	-21.00
Latitude:	62°01.2'S	Snow Thickness (m):	0.04
Longitude:	44°17.8'W	Total Ice Thickness (m):	1.12
		Freeboard (m):	0.10

Notes
Coring on flat first-year ice floe.
MET-Turbulence measurements.
Thickness profile; Mean ice thickness = 1.05 m (std. dev. = 0.074 m);
Mean snow depth 0.04m (std. dev. = 0.019 m).
Density core taken next to this core.

N0420311



Smooth First-year Ice: 21 July 1992

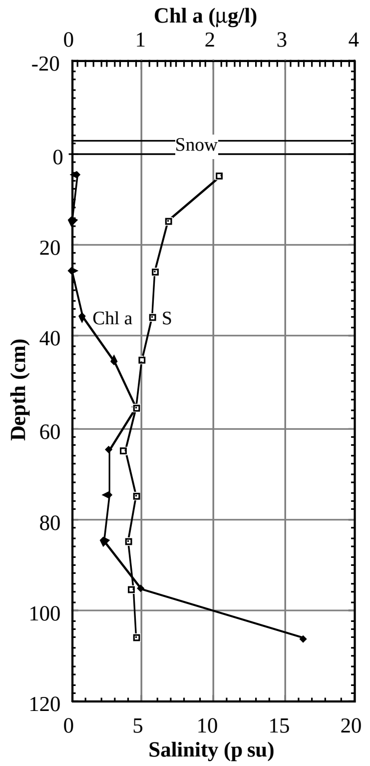


21 July 1992: N0420312

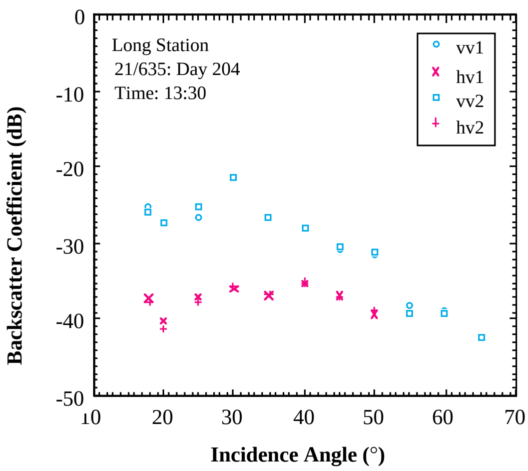
Ship Station Number:	21/635	Air Temperature (°C):	-23.70
Time:	19:00	Snow Surf. Temperature (°C):	-21.00
Latitude:	62°01.2'S	Snow Thickness (m):	0.04
Longitude:	44°17.8'W	Total Ice Thickness (m):	1.12
		Freeboard (m):	0.10

Notes
Coring on flat firstyear floe.
MET-Turbulence measurements.
Thickness profile.
Compare with Core 11 (T,S,Chl a,Texture).

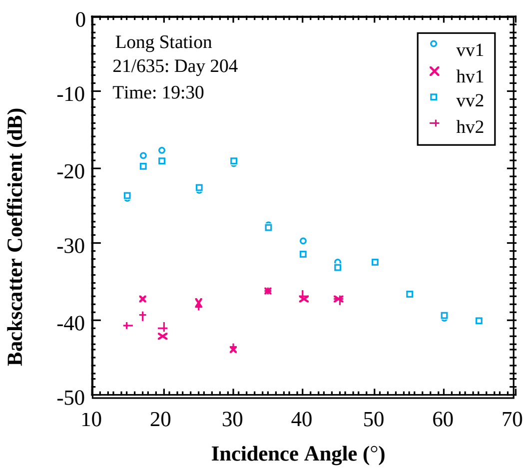
N0420312



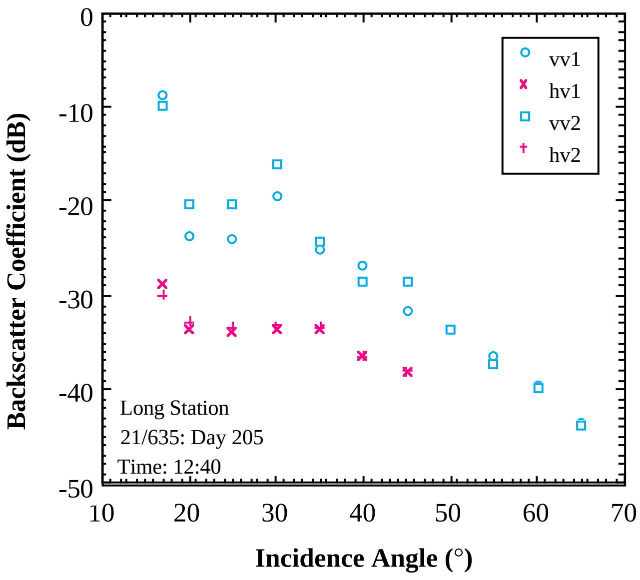
Smooth First-year Ice: 22 July 1992 (a)



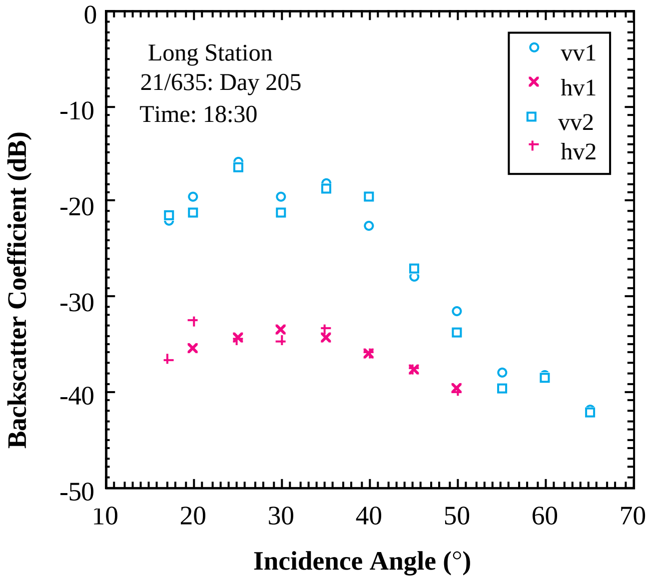
Smooth First-year Ice: 22 July 1992 (b)



Smooth First-year Ice: 23 July 1992 (n1)



Smooth First-year Ice: 23 July 1992 (n2)



24 July 1992: N0420601

Ship Station Number:	21/635	Air Temperature (°C):	-0.30
Time:	14:00	Snow Surf. Temperature (°C):	
Latitude:	61°52.9'S	Snow Thickness (m):	0.03
Longitude:	43°00.3'W	Total Ice Thickness (m):	1.00
		Freeboard (m):	

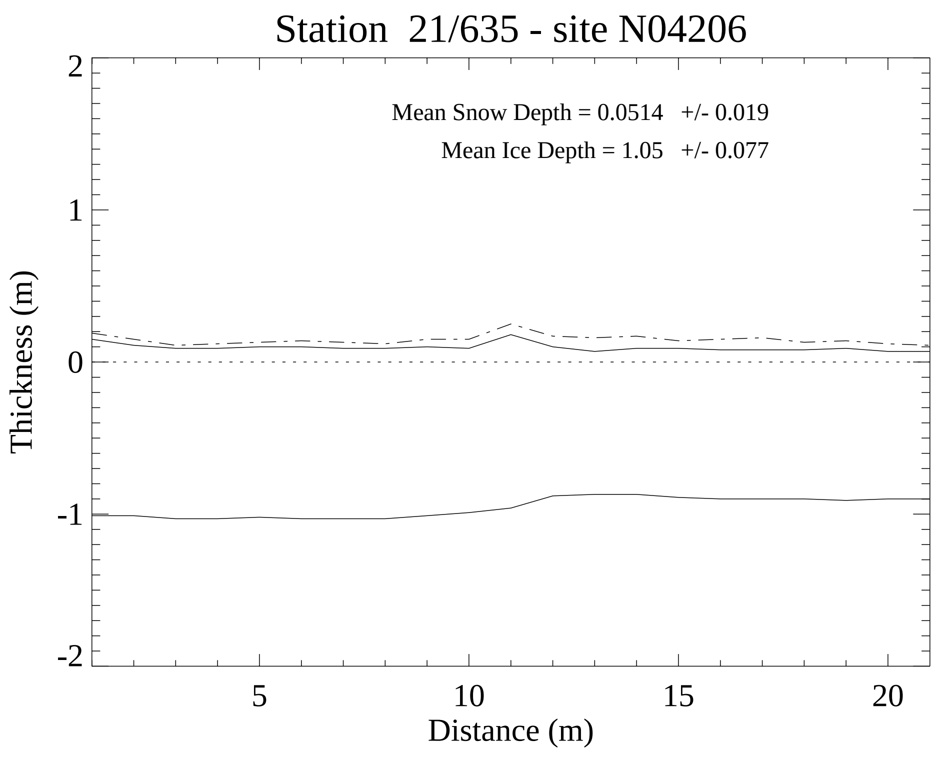
Notes
Same floe as 20311, core was taken in Radar swath. Second core 20602 next to thermistor stick (only T-measurement). Thickness profile.

24 July 1992: N0420602

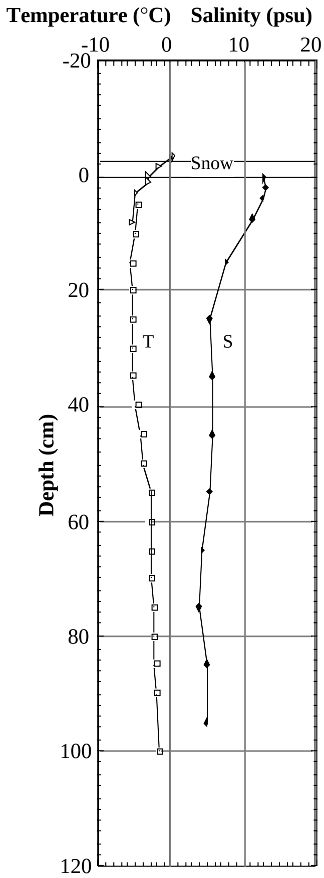
Ship Station Number:	21/635	Air Temperature (°C):	-0.30
Time:	14:00	Snow Surf. Temperature (°C):	
Latitude:	61°52.9'S	Snow Thickness (m):	0.03
Longitude:	43°00.3'W	Total Ice Thickness (m):	1.00
		Freeboard (m):	

Notes
Same floe as 20311, core was taken next to thermistor stick (only T-measurement). Second core 20601 in radar swath. Thickness profile.

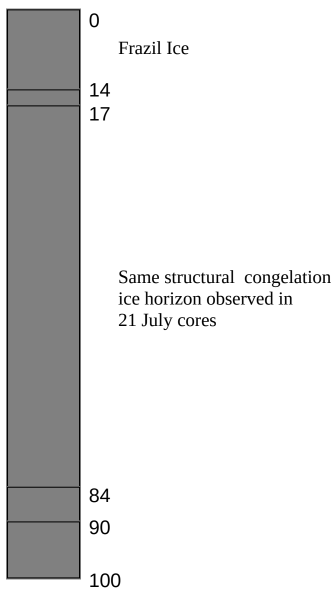
Thickness Profile Data



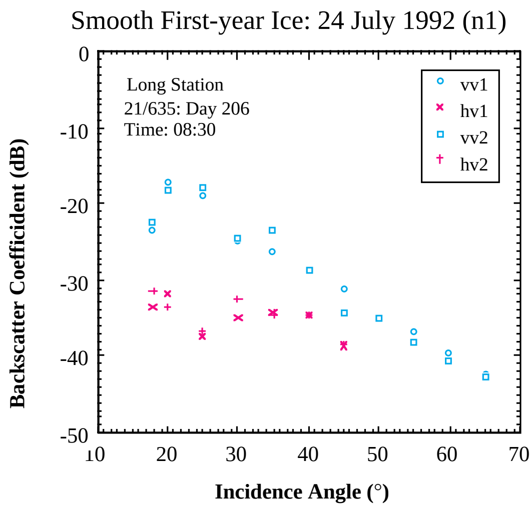
N0420601



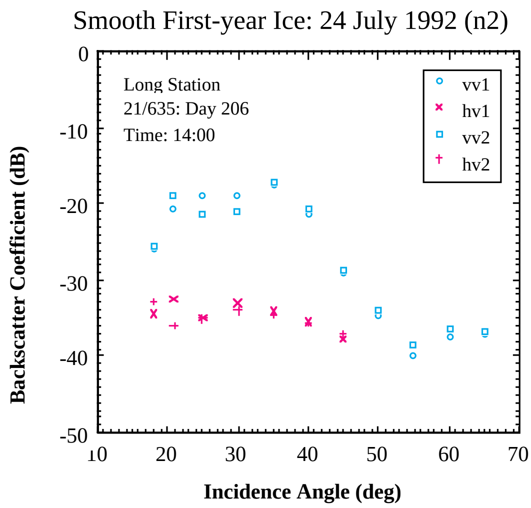
Temperature (°C) Salinity (psu)
-10 0 10 20
-20
0
20
40
60
80
100
120
Depth (cm)
Snow
T
S



0
Frazil Ice
14
17
Same structural congelation
ice horizon observed in
21 July cores
84
90
100



Smooth First-year Ice: 24 July 1992 (n1)
Long Station
21/635: Day 206
Time: 08:30
vv1
hv1
vv2
hv2
Backscatter Coefficient (dB)
Incidence Angle (°)
0
-10
-20
-30
-40
-50
10 20 30 40 50 60 70

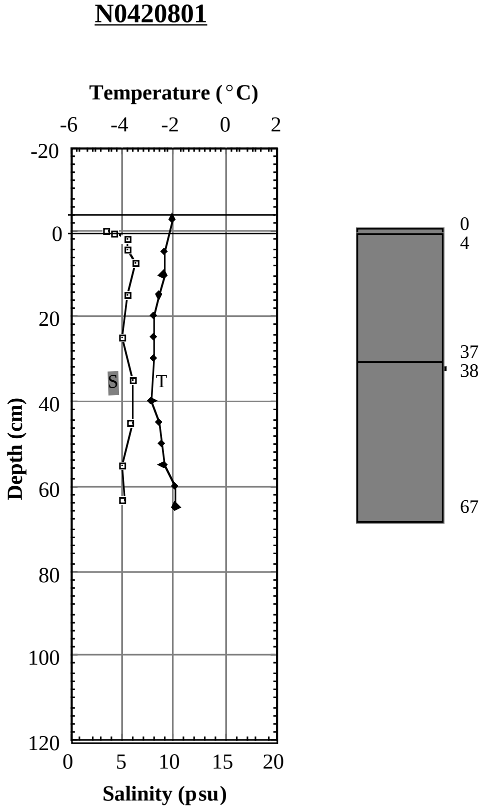


Smooth First-year Ice: 24 July 1992 (n2)
Long Station
21/635: Day 206
Time: 14:00
vv1
hv1
vv2
hv2
Backscatter Coefficient (dB)
Incidence Angle (deg)
0
-10
-20
-30
-40
-50
10 20 30 40 50 60 70

26 July 1992: N0420801

Ship Station Number:	21/637	Air Temperature (°C):	-2.05
Time:	15.00	Snow Surf. Temperature (°C):	
Latitude:	60°26.1'S	Snow Thickness (m):	0.02
Longitude:	46°59.8'W	Total Ice Thickness (m):	0.67
		Freeboard (m):	0.05

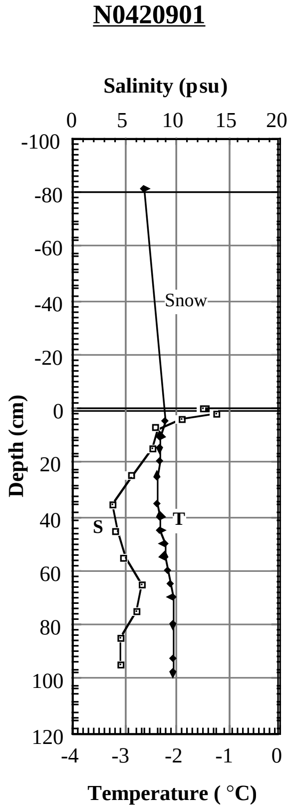
Notes
Coring on flat floe, surrounded by few big hummocks.
Refrozen melted snowcover.
Archive core, permeability measurement.
Brinesample.

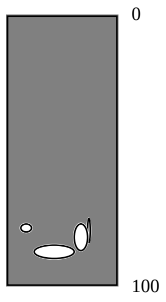


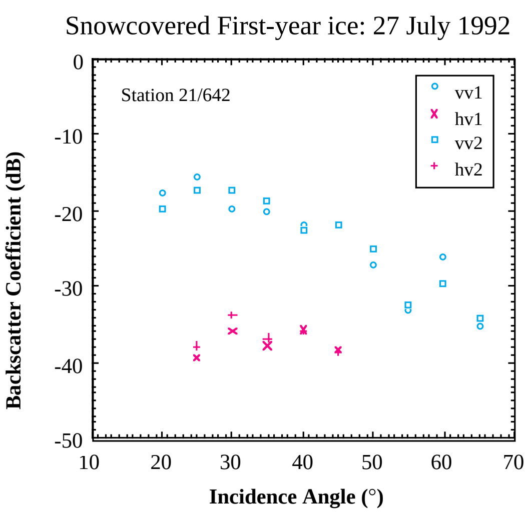
27 July 1992: N0420901

Ship Station Number:	21/642	Air Temperature (°C):	-2.62
Time:	16:50	Snow Surf. Temperature (°C):	
Latitude:	60°10.3'S	Snow Thickness (m):	0.80
Longitude:	49°19.4'W	Total Ice Thickness (m):	1.00
		Freeboard (m):	-0.07

Notes
Small flat floe with negative freeboard.
Archive Core



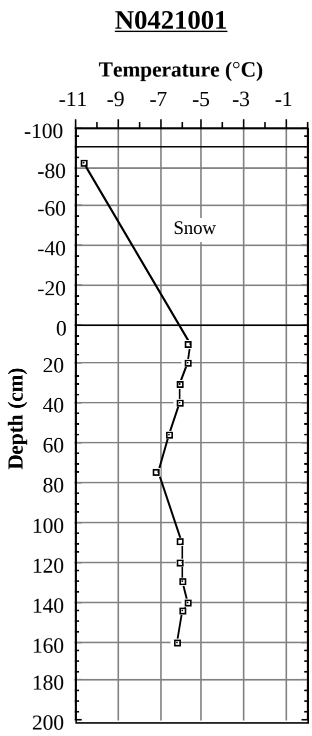


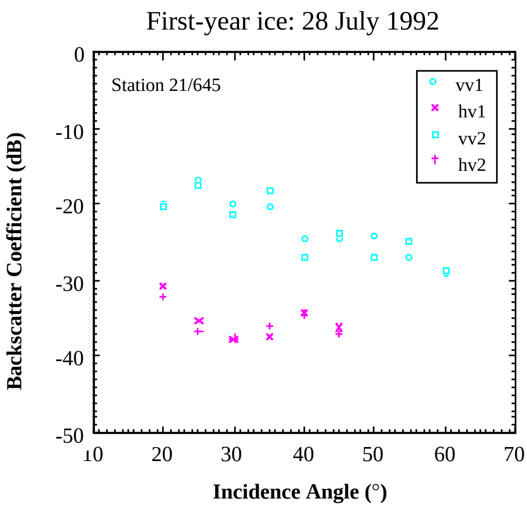


28 July 1992: N0421001

Ship Station Number:	21/645	Air Temperature (°C):	-10.60
Time:	08:00	Snow Surf. Temperature (°C):	
Latitude:	60°05.6'S	Snow Thickness (m):	0.80
Longitude:	50°18.5'W	Total Ice Thickness (m):	> 3.5
		Freeboard (m):	> 1.5

Notes
High freeboard floe in SAR-swath. Too thick to completely drill through.
Texture core (1.6 m), biology core 02 (3.5 m), saved for later laboratory analysis.



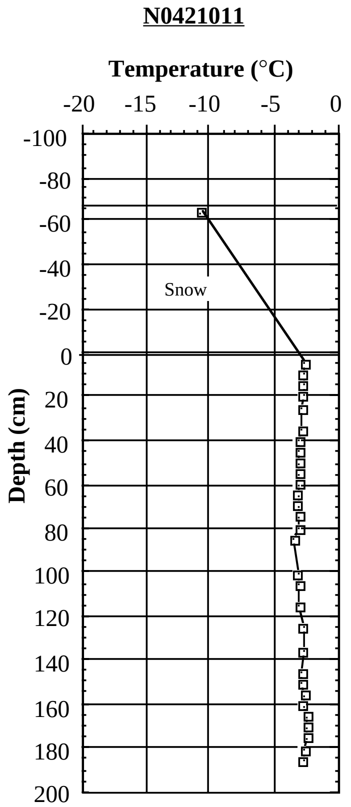


28 July 1992: N0421011

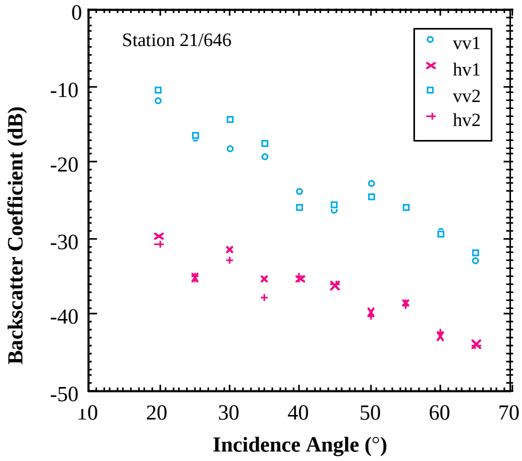
Ship Station Number:	21/647
Time:	17:30
Latitude:	59°39.3'S
Longitude:	50°29.9'W

Air Temperature (°C):	-14.80
Snow Surf. Temperature (°C):	-10.80
Snow Thickness (m):	0.63
Total Ice Thickness (m):	1.96
Freeboard (m):	-0.13

Notes
Second-year ice floe with negative freeboard.
Coring within radar footprint.
Archive core. Cores saved for later laboratory analysis.



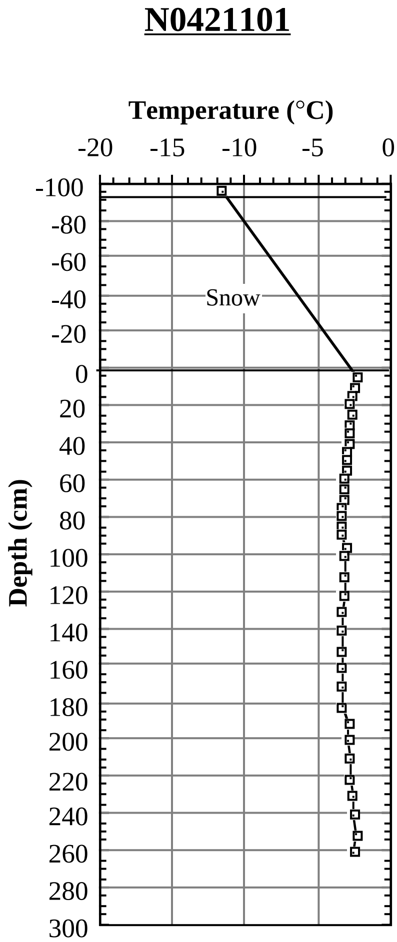
Second-year ice: 28 July 1992



29 July 1992: N0421101

Ship Station Number:	21/648	Air Temperature (°C):	-11.60
Time:	08:20	Snow Surf. Temperature (°C):	
Latitude:	59°08.1'S	Snow Thickness (m):	0.95
Longitude:	50°57.4'W	Total Ice Thickness (m):	2.63
		Freeboard (m):	-0.08

Notes
Flat piece of 50x50 m Multiyear Ice.
Archive core



29 July 1992: N0421111

Ship Station Number:	21/648	Air Temperature (°C):	-11.20
Time:	14.00	Snow Surf. Temperature (°C):	-8.40
Latitude:	59°28.0'S	Snow Thickness (m):	0.63
Longitude:	51°49.0'W	Total Ice Thickness (m):	2.60
		Freeboard (m):	0.00

Notes
Flat piece of 50x50 m multi-year ice, entered by helicopter.
Permeability measurement.